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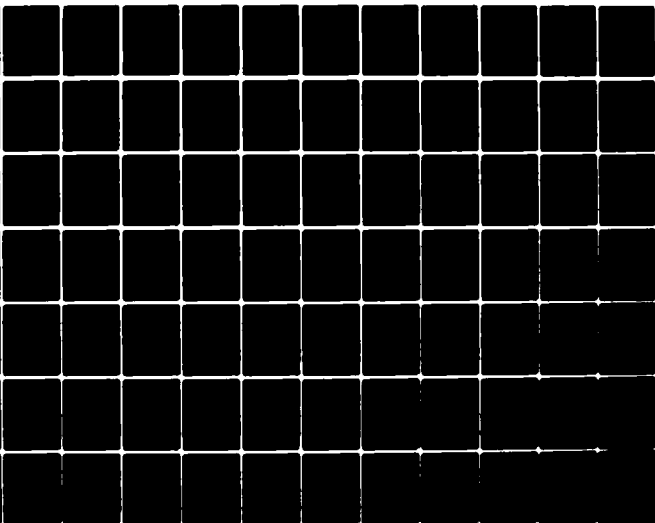
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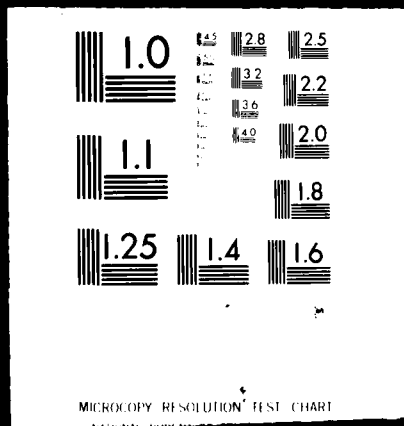
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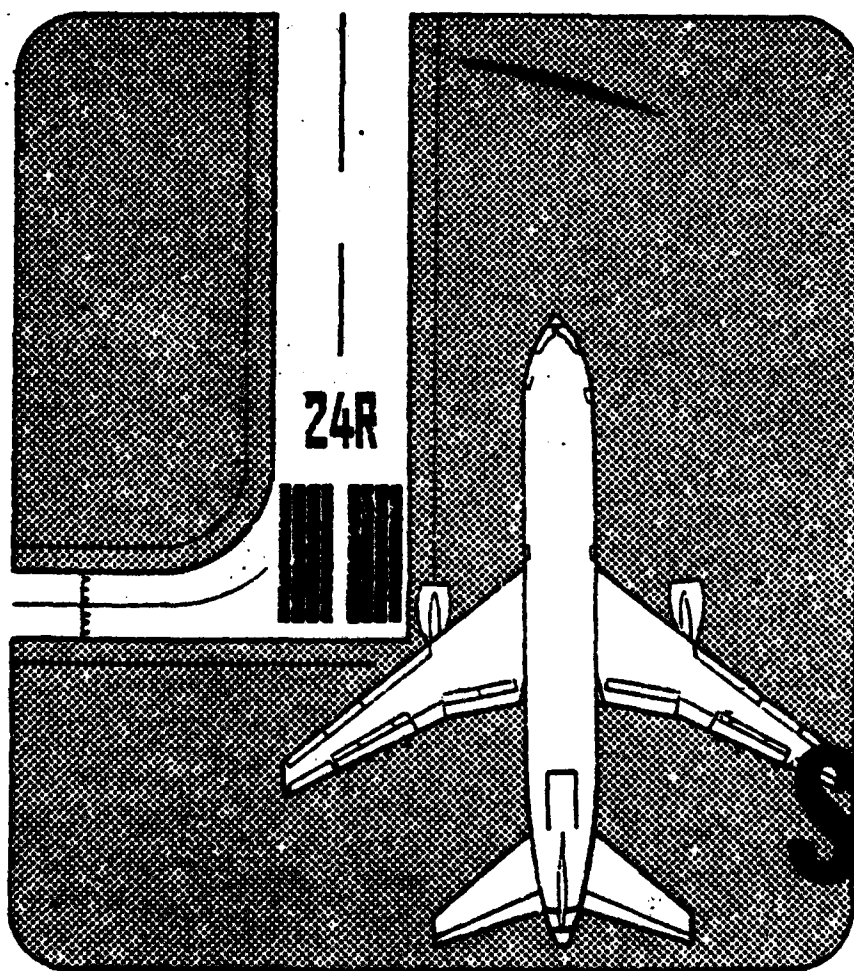
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LEVEL ^{11C} LOS ANGELES INTERNATIONAL AIRPORT TECHNICAL PLAN

AIRPORT IMPROVEMENT
TASK FORCE DELAY STUDIES



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Peat, Marwick, Mitchell & Co.

SEPTEMBER 1978

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SAN FRANCISCO INTERNATIONAL AIRPORT

SAN FRANCISCO, CALIFORNIA 94128

Telephone: (415) 347-9521

September 9, 1978

Federal Aviation Administration
800 Independence Avenue, S.W.
Washington, D.C. 20591

Attention: Mr. J. R. Dupree (ALG-312)

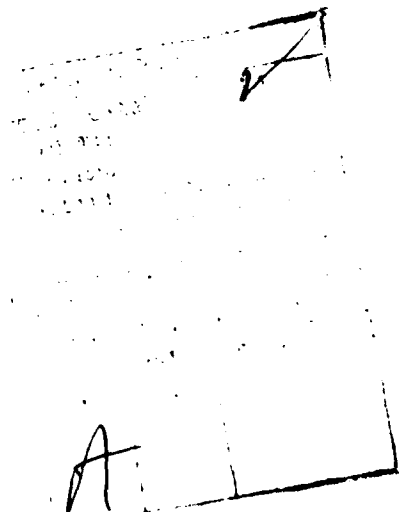
Re: Los Angeles Technical Plan
Contract No. DOT-FA77WA-3961

Gentlemen:

In accordance with the subject contract, Peat, Marwick Mitchell & Co. (PMM&Co.) is pleased to submit the Technical Plan for the performance of the delay studies at Los Angeles International Airport.

Respectfully submitted,

Peat, Marwick, Mitchell & Co.
PEAT, MARWICK, MITCHELL & CO.



LOS ANGELES INTERNATIONAL AIRPORT TECHNICAL PLAN,

Airport Improvement Task Force Delay Studies .

Contract DOT-FA77WA-3961

Prepared for

U.S. Department of Transportation
Federal Aviation Administration

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Peat, Marwick, Mitchell & Co.
San Francisco, California

11 September 1978

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ACKNOWLEDGMENT

Except for minor revisions, this technical plan is identical to a draft technical plan provided by Mr. John R. Vander Veer, of the FAA National Aviation Facilities Experimentation Center in Atlantic City. Peat, Marwick, Mitchell & Co. appreciates the assistance of NAFEC in this activity.

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I. INTRODUCTION

This technical plan has been designed for use by FAA Headquarters, the Los Angeles Task Force, NAFEC, and PMM&Co. during the Los Angeles International Airport Delay Improvement Study. The plan consists of three parts and includes recommendations for the following:

- Approach and Milestones--establishes work tasks, responsibilities, and the interrelationship of Task Force participants, as well as major milestones representing decision/approval/redirection points in the study, (Chapter II)
- Experimental Design--describes criteria and recommendations for model runs to prepare delay estimates, (Chapter III)
- Data Requirements--specifies model inputs and outputs, and data collection needs and responsibilities. (Chapter IV)

Task Force Objectives

FAA Headquarters established the following objectives to guide the delay analysis:

- Identify causes of delay associated with terminal airspace, airfield, and apron/gate area operations.
- Determine delay reduction benefits of alternative air traffic control (ATC) procedures, Facilities and Equipment (F&E), Airport Development Aid Program (ADAP), and Research, Engineering and Development (R,E&D) improvement options for immediate, near-term (pre-1985) and long-term (post-1985) implementation.
- Establish the relationships between air traffic demand and delay in the present and in the future.

This technical plan describes a recommended approach for the Los Angeles Task Force delay studies in response to these objectives and to the specific needs of the Los Angeles Task Force. The delay studies are oriented to assist the

Task Force in evaluating high-priority airfield improvements that can be implemented in the near future, and to assist FAA Headquarters in evaluating the potential benefits of its research and development activities.

Approach and Milestones

Chapter II of this technical plan identifies specific milestones and task responsibilities for FAA Headquarters, the Los Angeles Task Force, NAFEC, and PMM&Co.

Six major tasks are identified:

- Develop Technical Plan and Experimental Design
- Collect Input Data
- Perform Model Calibration
- Run Delay Models
- Interpret Delay Results
- Develop Airport Delay Analysis Report

In addition, coordination meetings at key decision points and for purposes of monitoring Task Force progress are discussed in Chapter II together with recommendations for meeting objectives, agendas, and preparation responsibilities.

Experimental Design

Chapter III of this technical plan describes the process of developing and selecting experiments to be used for estimating delays. This process is referred to as "experimental design."

Because of the large number of possible near-term and long-term improvements, as well as the variety of operating conditions to be considered (runway use, weather, demand level, ATC system scenarios, etc.), a screening process was used to select the delay experiments that are recommended to meet the stated objectives.

As noted in Chapter III, experiments are planned to be conducted in two stages so that final decisions on experiments scheduled for the second stage can be reviewed after the results of the first-stage experiments are evaluated.

Data Requirements

A series of models are available to assist the Task Force in computing delays to aircraft. These models are outlined in Appendix A.

The PMM&Co. airfield simulation model is available for computations of hourly and/or daily delays to aircraft. The simulation model also computes aircraft flow rates and travel times.

The annual delay model is available for computations of annual delays to aircraft. The annual delay model also computes distributions of average aircraft delays.

A number of additional models are also available to the Task Force, including (1) a weather model to analyze weather occurrence at an airport based on raw airport climatological data from the National Weather Records Center, and (2) an analytical runway capacity model that computes estimates of hourly runway capacity.

Data needs for model calibration and model runs to prepare delay estimates are discussed in Chapter IV. Some data are available from the Los Angeles Interim Report,* some data will be derived from an analysis of historical data, and other data will be collected by field observations.

A preliminary airfield network reflecting the current configuration for Los Angeles International Airport was prepared from available data and is set forth in Figure I-1.

*Los Angeles International Airport Improvement Program, Interim Report, September 1977.

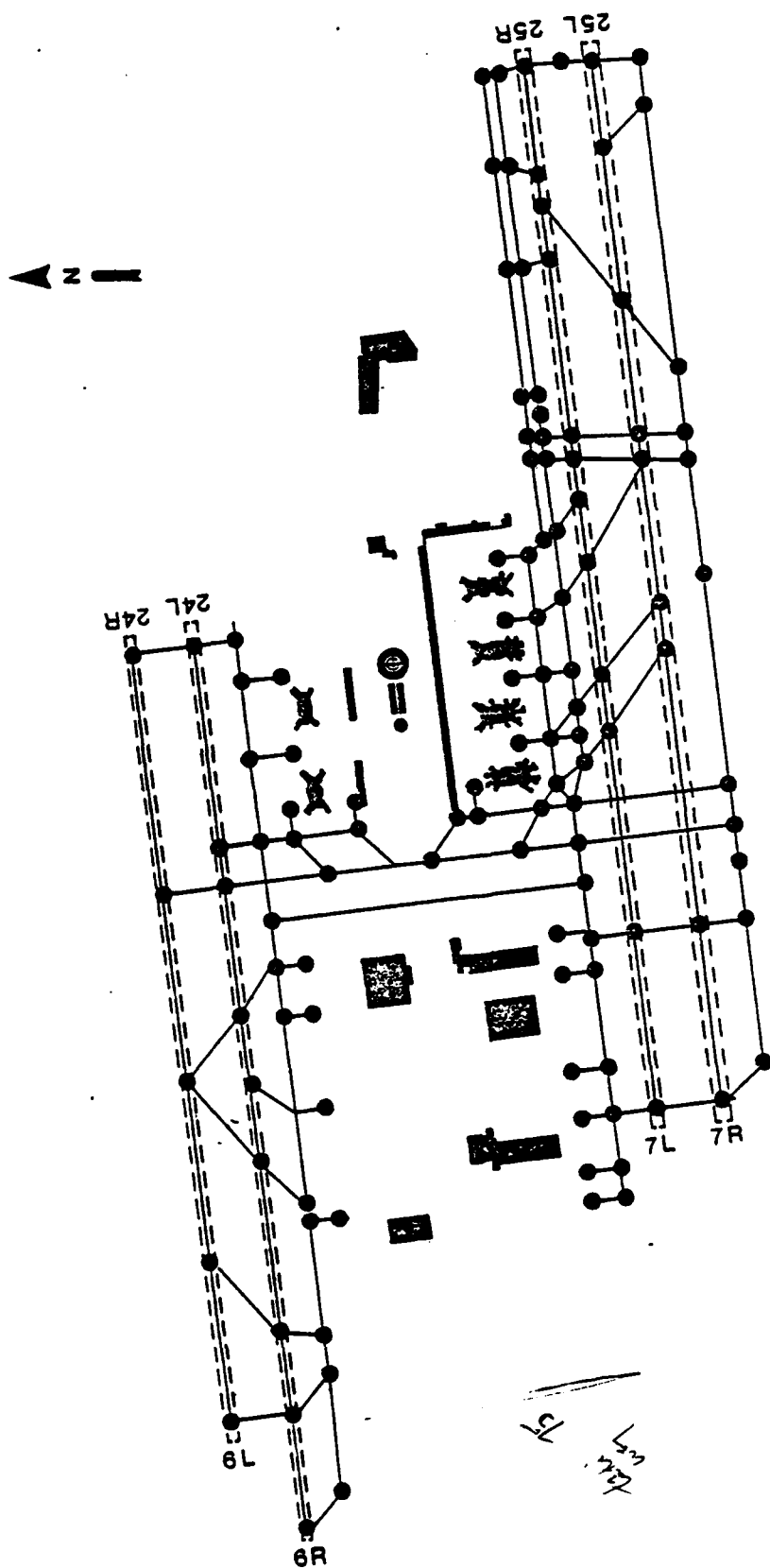


Figure I-1
 PRELIMINARY AIRFIELD NETWORK
 Los Angeles International Airport
 Delay Improvement Study
 PMM&Co. September 1978

II. APPROACH AND MILESTONES

Organization

The organizational framework for the Los Angeles Task Force activity is shown in Figure II-1.

The FAA Western Region manages the activities of the Los Angeles Task Force. Executive direction for the activities is provided by the FAA Air Traffic and Airways Facilities Program Management Staff (ATF-4).

The FAA Office of Systems Engineering Management (AEM-100) manages the technical support for the Task Force analysis, including resources from NAFEC, PMM&Co., and other support.

Work Tasks and Responsibilities

Six major tasks are to be performed by the Los Angeles Task Force, FAA Headquarters, NAFEC, and PMM&Co.:

1. Develop Technical Plan and Experimental Design
2. Collect Input Data
3. Perform Model Calibration
4. Run Delay Models
5. Interpret Delay Results
6. Develop Task Force Delay Analysis Report

Task interrelationships are given in Figure II-2. Descriptions of the six major tasks are given below.

Task 1--Develop Technical Plan and Experimental Design.
NAFEC prepares a draft technical plan for the airport. The technical plan describes the recommended method of approach for the conduct of the delay studies at the airport, including a recommended airport-specific experimental design, task responsibilities, and time schedules. PMM&Co. prepares the final technical plan based on the draft technical plan prepared by NAFEC.

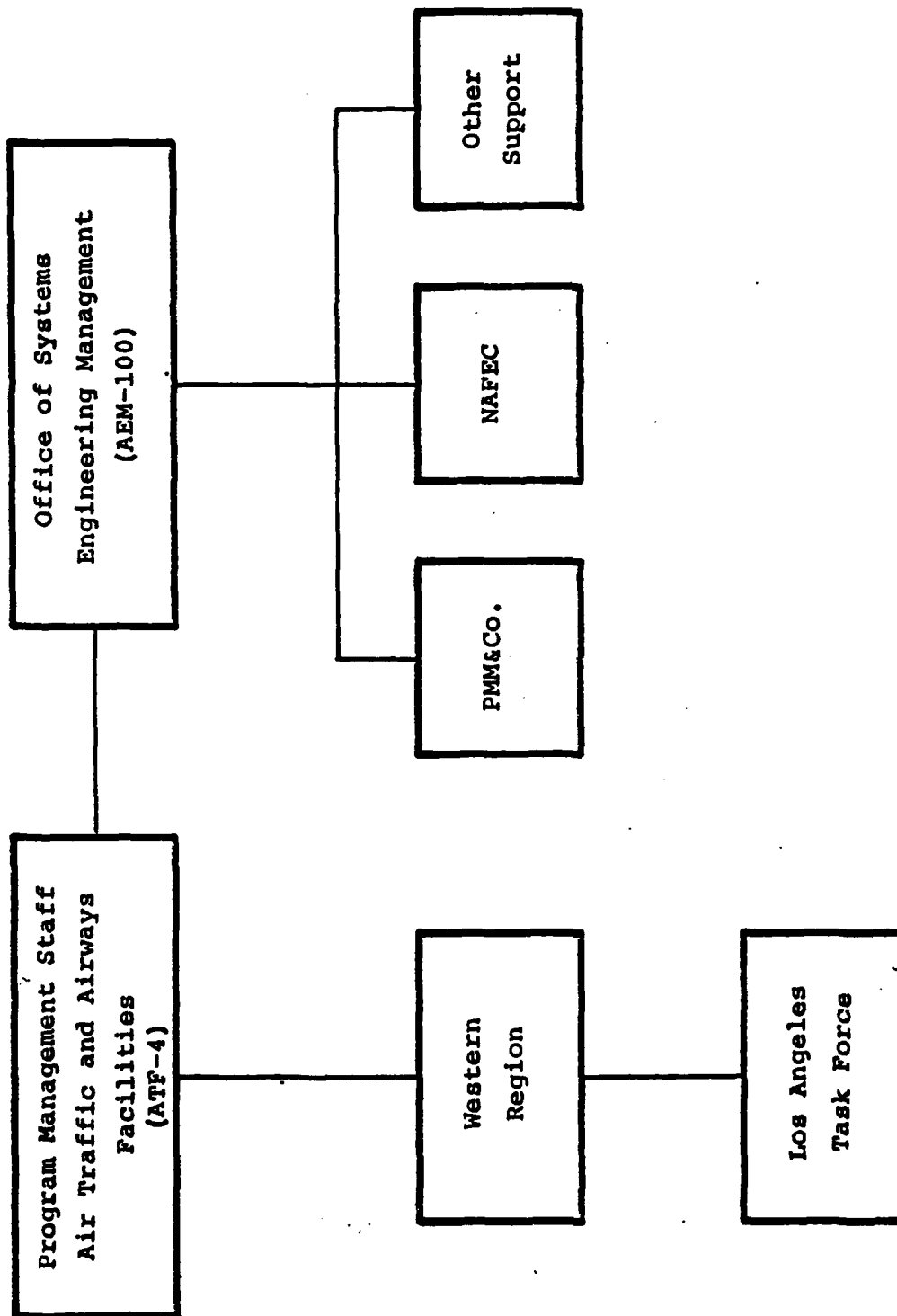


Figure II-1

ORGANIZATIONAL FRAMEWORK
Los Angeles International Airport
Delay Improvement Study
PMM&Co. September 1978

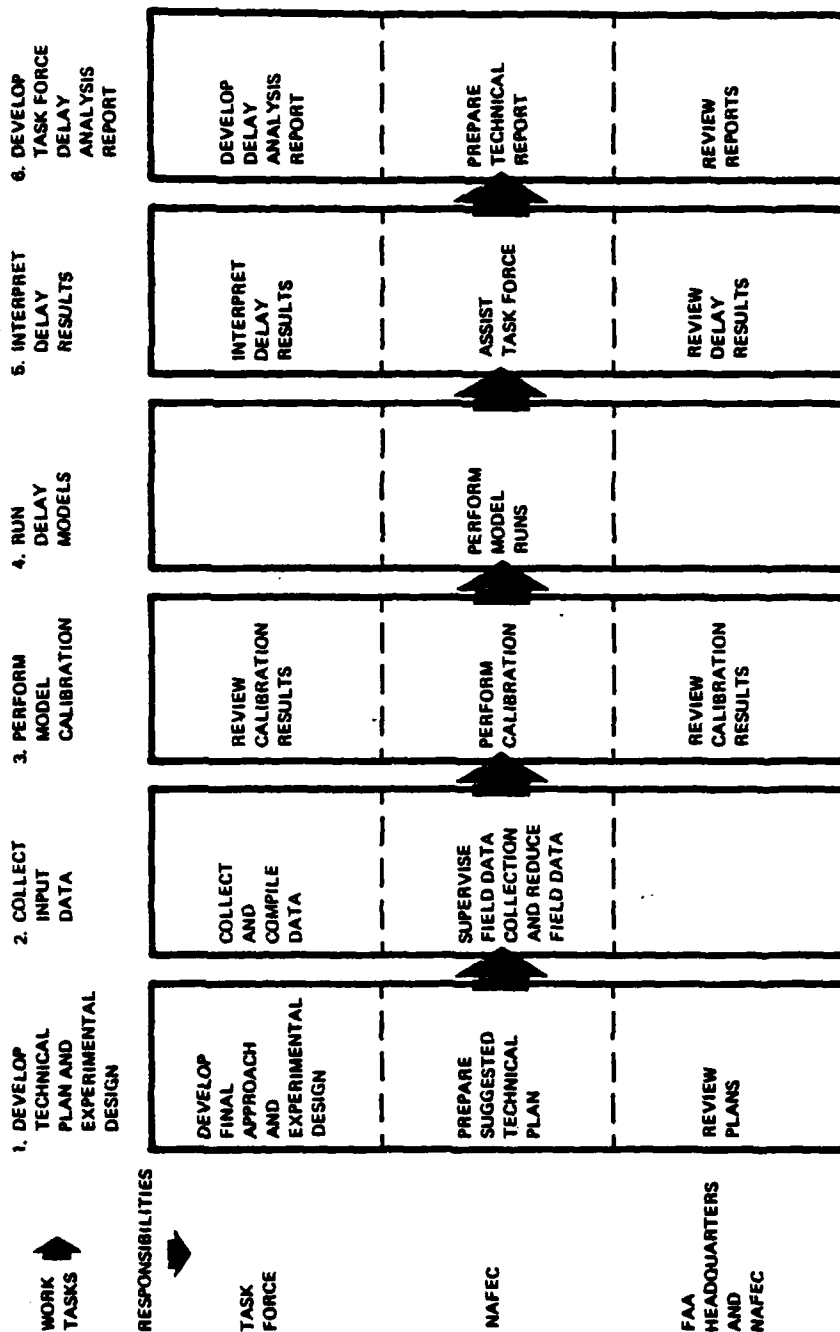


Figure II-2
 AIRPORT TASK SEQUENCE
 Los Angeles International Airport
 Delay Improvement Study
 PMM&Co. September 1978

The plan also identifies methods for obtaining delay estimates using the PMM&Co. airfield simulation model, annual delay model, or other techniques as appropriate. The Task Force and FAA Headquarters review the plan and the Task Force develops a final technical approach and experimental design.

Task 2--Collect Input Data. NAFEC describes data requirements for applying the delay model(s) for developing delay estimates. The Task Force (with assistance from NAFEC and PMM&Co.) establishes data needs for delay experiments, and collects, compiles, and reviews the data. The data to be collected include field data, data currently in the possession of Task Force members, and data to be provided by NAFEC and PMM&Co. The field data are reduced by NAFEC using currently available data reduction computer programs.

Task 3--Perform Model Calibration. On the basis of data obtained in Task 2, NAFEC consolidates the data, performs calibration model runs, and demonstrates results to the Task Force. The model calibration assures that the simulation model correctly reflects the site-specific airport situation.

Task 4--Run Delay Models. NAFEC performs model runs for delay estimates. Models used may include the airfield simulation model, as well as ancillary models such as the annual delay model. The model runs result in the production of delay estimates for the experiments established in the experimental design.

Task 5--Interpret Delay Results. The Task Force (with assistance from NAFEC and PMM&Co.) interprets the delay estimates. Interpretation of the total set of delay estimates provides guidance in evaluating the impact on delay (for the appropriate study cases) of one or more of the following: (1) changes in demand level, including aircraft mix; (2) changes in runway use patterns; (3) changes to runway/taxiway/apron areas; (4) new ATC procedures, including changes in separation standards; and (5) navigation aids and other ATC improvements.

Task 6--Develop Task Force Delay Analysis Report. NAFEC prepares a draft technical report that documents the delay analyses performed. PMM&Co. prepares a technical report based on the draft report prepared by NAFEC. The

Task Force and FAA Headquarters review the technical report. The Task Force develops a Delay Analysis Report that includes (1) the conclusions drawn by the Task Force from the delay analyses and (2) a set of recommendations for reducing delays to aircraft at the airport.

Milestones and Schedule

A series of overall milestones are recommended concerning the completion of significant tasks, delivery of products, and decision points of Los Angeles Task Force activities, as listed in Table II-1.

Task Force Meetings. At key decision points and for purposes of monitoring progress in relation to the study milestones, a series of Task Force meetings are recommended.

The specific objectives and outputs of the meetings are summarized in Table II-2. Suggested details on the objectives, agendas, and preparation responsibilities for these meetings are shown in the following list.

Task Force Meeting No. 1:

a. Objectives

Briefings will be given to bring Task Force members up to date on plans, schedules, and responsibilities. The technical plan and experimental design will be reviewed, and a plan will be established to collect and compile the required model input data to obtain delay estimates.

b. Agenda

1. Introduction and background
2. Presentation on technical plan
3. Presentation and discussion of data requirements for model calibration and delay experiments
4. Establishment of data collection and reduction procedure (including commitment of personnel and data responsibilities)

Table II-1

TASK FORCE AIRPORT MILESTONES
Los Angeles International Airport Delay Improvement Study

<u>Milestone No.</u>	<u>Milestone</u>	<u>Target Completion Date</u>
1	Review technical plan	September 12, 1978
2	Identify data requirements	September 12, 1978
3	Collect field data	September 29, 1978
4	Consolidate calibration data	November 1, 1978
5	Complete model calibration	November 23, 1978
6	Consolidate delay input data	November 23, 1978
7	Complete delay runs	January 31, 1979
8	Interpret impact of delay results	February 15, 1979
9	Review draft reports	March 15, 1979
10	Prepare reports	March 30, 1979

Table II-2

RECOMMENDED TASK FORCE MEETINGS
Los Angeles International Airport Delay Improvement Study

<u>Meeting No.</u>	<u>Objectives</u>	<u>Outputs</u>	<u>Target Meeting Date</u>
1	Give briefing on technical plan, experimental design, and data requirements	Comments on technical plan and data requirements for calibration and delay study	September 12, 1978
2	Review calibration data and finalize experimental design	Calibration data and experimental design	November 1, 1978
3	Review calibration results and delay input data	Approved model and input data for delay studies	December 7, 1978
4	Review Stage 1 delay runs and plan for Stage 2 delay runs	Updated Stage 2 delay input data	January 11, 1979
5	Review and interpret impacts of delay results	Impacts of delay results	February 15, 1979
6	Review draft PM&Co. technical report and Task Force delay analysis report	Comments on draft report	March 15, 1979

5. Establishment of experimental design subgroup
6. Working session on experimental design
7. Definition of procedure to develop demand forecasts
8. Description of tasks to be performed prior to Task Force Meeting No. 2
9. Preparations for Task Force Meeting No. 2

c. Preparation Responsibilities

NAFEC will develop briefing materials on the technical plan, experimental design, data requirements, and field data collection and Task Force members will read and review the technical plan. The Task Force Chairman will work with FAA Headquarters to determine resource needs and commitments.

Task Force Meeting No. 2:

a. Objectives

The Task Force will review the data for model calibration, review progress on development of model input data for delay estimates, and finalize the experimental design.

b. Agenda

1. Review of minutes of Task Force Meeting No. 1
2. Presentation on model calibration data collection and reduction
3. Working session on calibration data
4. Selection of input and output data for model calibration run
5. Review of progress on data development for delay estimates

6. Review of experimental design
7. Finalization of demand forecast data
8. Description of tasks to be performed prior to Task Force Meeting No. 3
9. Arrangements for Task Force Meeting No. 3

c. Preparation Responsibilities

NAFEC, and the Task Force will develop briefing materials describing model input data collected and reduced. The experimental design subgroup will develop a recommended experimental design for review and discussion.

Task Force Meeting No. 3:

a. Objectives

The Task Force will review the model calibration results and establish the input data for delay estimates.

b. Agenda

1. Review of minutes of Task Force Meeting No. 2
2. Presentation and discussion of model calibration results
3. Presentation and discussion of input data for delay estimates
4. Select input data for delay estimates
5. Description of tasks to be performed prior to Task Force Meeting No. 4
6. Arrangements for Task Force Meeting No. 4

c. Preparation Responsibilities

NAFEC will prepare briefing materials describing model calibration results and input data developed for delay estimates. The Task Force will prepare briefing materials describing input data developed for delay estimates.

Task Force Meeting No. 4:

a. Objectives

The Task Force will review results of Stage 1 delay estimates and update requirements for Stage 2 delay estimates.

b. Agenda

1. Review of minutes of Task Force Meeting No. 3
2. Interpretation and discussion of Stage 1 delay estimates
3. Definition of requirements for Stage 2 delay estimates
4. Description of tasks to be performed prior to Task Force Meeting No. 5
5. Arrangements for Task Force Meeting No. 5

c. Preparation Responsibilities

NAFEC will develop briefing materials on the results of Stage 1 delay estimates and input data for Stage 2 delay estimates.

Task Force Meeting No. 5:

a. Objectives

The Task Force will review the results of Stage 2 delay estimates and interpret the

impacts of the results. The Task Force will also review the schedules and outlines of the Task Force delay analysis report and NAFEC/PMM&Co. technical report.

b. Agenda

1. Review of minutes of Task Force Meeting No. 4
2. Presentation of Stage 2 delay estimates
3. Interpretation of impact of delay results
4. Review of Task Force and NAFEC/PMM&Co. report outlines and completion schedules
5. Description of tasks to be performed prior to Task Force Meeting No. 6
6. Arrangements for Task Force Meeting No. 6

c. Preparation Responsibilities

NAFEC will develop briefing materials on results of Stage 2 delay estimates and on the target schedule and outline for the NAFEC/PMM&Co. technical report. The Task Force will develop briefing materials on the schedule and preliminary outline of the Task Force delay analysis report.

Task Force Meeting No. 6:

a. Objectives

The draft technical report prepared by NAFEC/PMM&Co. and the delay analysis report prepared by the Task Force will be reviewed. Plans to work toward implementation of improvements will be discussed.

b. Agenda

1. Review of minutes of Task Force Meeting No. 5

2. Presentation and discussion of draft NAFEC/PMM&Co. technical report
3. Presentation and discussion of draft Task Force delay analysis report
4. Description of remaining reporting and implementation activities
5. Concluding remarks by FAA Headquarters, including discussion of Task Force recommendations

c. Preparation Responsibilities

The Task Force and NAFEC will develop briefing materials on the draft reports. The Task Force will review the draft NAFEC/PMM&Co. technical report and draft Task Force delay analysis report.

Schedule. A suggested schedule for performance of the various tasks is illustrated in Table II-3. The schedule is keyed to the milestones and Task Force meetings described previously, as well as the time requirements and interactions of the various tasks shown in Figure II-2. The suggested schedule also reflects the planning for other Task Force airports to conserve resources and overall schedules.

Table II-3

SUGGESTED TASK FORCE ACTIVITY SCHEDULE
Los Angeles International Airport Delay Improvement Study

<u>Task or Major Subtask</u>	<u>Target Start Date</u>	<u>Target Completion Date</u>
1 Develop recommended Technical Plan and Experimental Design	August 22, 1978	September 8, 1978
2 Collect input data		
Establish input data requirements	August 22, 1978	August 30, 1978
Collect field data	September 25, 1978	September 29, 1978
Collect Task Force data	September 12, 1978	October 6, 1978
Collect FAA ATC system scenario data	September 12, 1978	October 6, 1978
Consolidate input data for delay estimates	October 6, 1978	November 23, 1978
Review input data	November 16, 1978	December 7, 1978
Update Stage 2 data	October 6, 1978	October 26, 1978
3 Perform model calibration		
Consolidate calibration data	October 6, 1978	November 1, 1978
Perform calibration model run	November 1, 1978	November 16, 1978
Review calibration results	November 16, 1978	December 7, 1978
4 Run delay models		
Perform Stage 1 runs	December 7, 1978	January 4, 1979
Review Stage 1 runs	January 4, 1979	January 11, 1979
Perform Stage 2 runs	January 17, 1979	January 31, 1979
5 Interpret delay results		
Interpret Stage 1 results	January 4, 1979	January 11, 1979
Interpret Stage 2 results	February 1, 1979	February 8, 1979
Review delay results	February 1, 1979	February 15, 1979
6 Develop PMSCo. technical report and Task Force delay analysis report		
Prepare draft reports	February 15, 1979	February 28, 1979
Review draft reports	February 28, 1979	March 15, 1979
Prepare final reports	March 15, 1979	March 30, 1979

III. EXPERIMENTAL DESIGN

The process of selecting and developing delay experiments to be used for estimating delay values is referred to as "experimental design." Because there are many combinations of possible near- and long-term improvements as well as a variety of operating conditions to be considered (runway use, weather, demand level, ATC scenarios, etc.), one important activity was the selection of the combinations of improvements and operating conditions for recommended experiments.

The process of screening and evaluation of possible experiments used in preparing the technical plan reflects the following:

- Objectives of the Los Angeles Task Force and FAA Headquarters
- Results of the capacity phase of the Los Angeles Task Force Study documented in the Interim Report
- Improvements and changing conditions since the Los Angeles Interim Report
- Impact of near- and long-term improvements on delay reduction (reflecting the frequency of impact, as well as the magnitude and importance of the impact during critical periods at the airports, e.g., high delays in low visibility conditions)
- ATC system scenarios considered likely in the future

To achieve Task Force objectives, two types of delay estimates are required: (1) hourly and/or daily delays, which may be produced by the airfield simulation model, and (2) annual delays, which may be produced by the annual delay model.

Descriptions of the airfield simulation model, annual delay model, and other ancillary models available to the Task Force are presented in Appendix A.

Hourly and/or daily delay estimates will be used:

- To assess details of aircraft operations on the existing airfield
- To estimate the impact of near-term (pre-1985) improvements

Annual delay estimates will be used:

- To estimate the impact of long-term (post-1985) improvements
- To facilitate economic analysis in both the near term and long term

To achieve these objectives, a set of experiments is recommended for three time frames: today, pre-1985, and post-1985. The experiments will estimate aircraft delays that may occur in these three time frames.

Delay experiments are recommended that will illustrate the delays to aircraft that may occur in the future under alternative assumptions or "scenarios."

The first scenario is the situation "most likely" to occur in a particular time frame--for example, the pre-1985 most likely scenario.

To estimate aircraft delays for this scenario, it is necessary to establish (1) the most likely level of demand, (2) the package of near-term improvements that is most likely to be implemented, and (3) the most likely ATC system scenario. Development of this scenario requires judgments by the Task Force on the most likely situation in the pre-1985 time frame.

The impact of individual improvement items can then be assessed by performing additional experiments and comparing the resulting delays with the delays estimated for the most likely scenario.

For example, assume that an additional taxiway is planned for implementation in the post-1985 time frame. Then the most likely pre-1985 scenario will exclude this additional taxiway. The impact of the additional taxiway on delays in the pre-1985 time frame can be estimated by comparing two delay estimates: (1) delays computed for the pre-1985 most likely scenario (without the additional taxiway), and

(2) delays computed by an additional experiment that adds the additional taxiway to the package of most likely pre-1985 near-term improvements.

Therefore, delay experiments are recommended that establish most likely delays to aircraft and estimate delay savings associated with individual improvement items.

Thirty-four experiments are recommended for Los Angeles International Airport, as listed in Table III-1.

The experiments are divided into two stages. This permits the results of the first-stage experiments to influence and possibly redirect the second-stage experiments.

Table III-1 shows that 25 delay experiments are planned to be performed with the airfield simulation model (ASM), and 9 experiments are planned to be performed with the annual delay model (ADM).

For each delay experiment, Table III-1 also shows the study case, arrival and departure runways, weather, and the time frame for the demand, ATC system scenario, and near-term improvements.

Simulation Model Experiments

Twenty-five simulation model experiments are recommended to compute hourly and/or daily delays to aircraft.

To establish the appropriate delay experiments, the capacity analyses documented in the Los Angeles Interim Report were examined, and discussions were held with Task Force members. The interim report identified 2 study cases (combinations of runway use and weather). The 2 study cases and values of baseline hourly runway capacity considered in the Los Angeles Interim Report are depicted in Figure III-1, together with 7 additional study cases suggested for inclusion in the delay study.

Six baseline experiments (Experiments 1 through 6) are recommended to assess delays to aircraft in 1977 for different runway uses and weather conditions.

Four additional baseline experiments (Experiments 7 through 10) are recommended to assess delays to aircraft in 1982 for different runway uses and weather conditions.

Conceded all cur 2 arrival runways

Table III-1

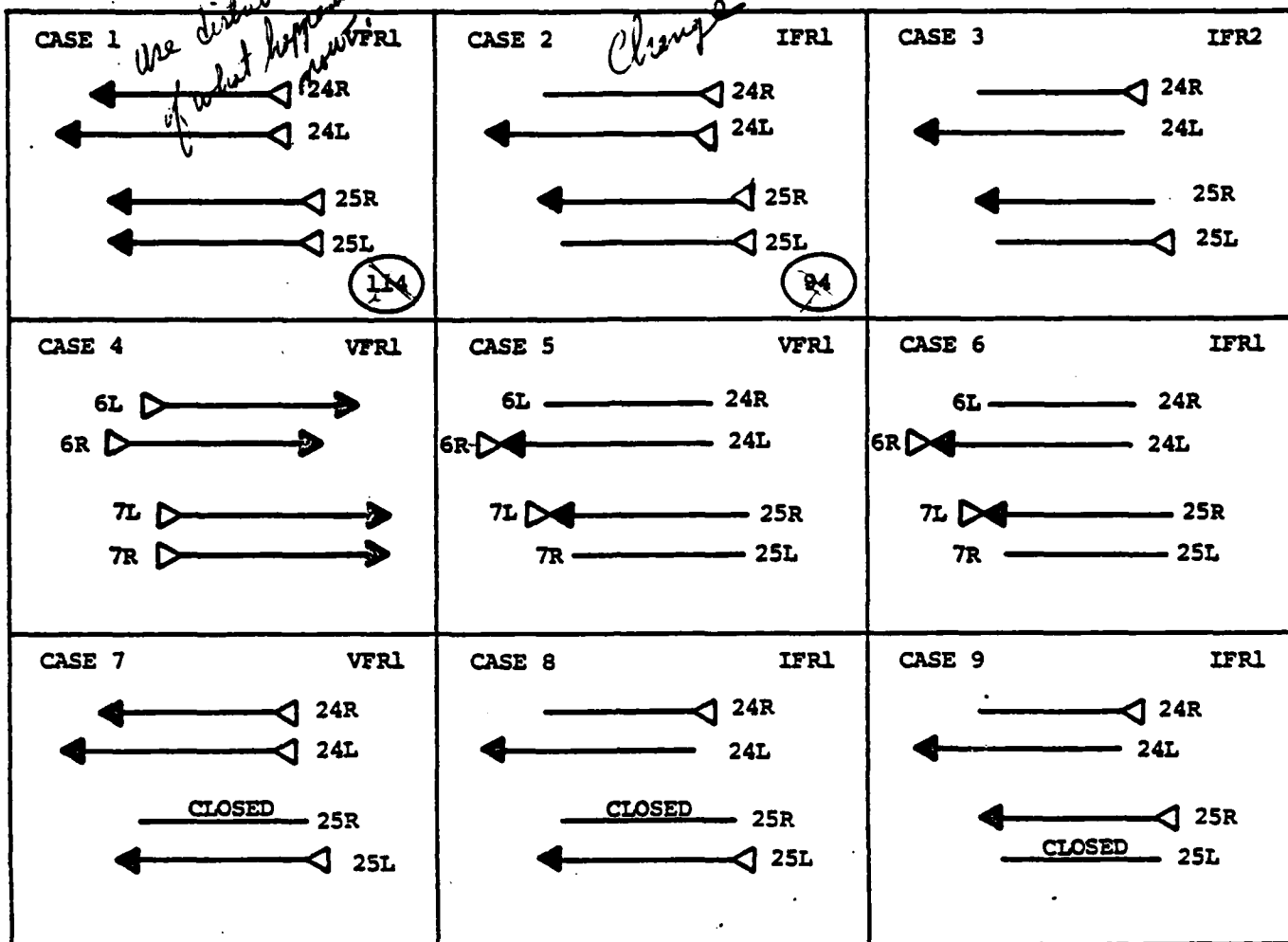
LOS ANGELES DELAY EXPERIMENTS

Experiment number	Model	Study case	Arrival runways	Departure runways	Weather	Demand	ATC System b scenario	Short-term c improvements
Stage 1 Experiments								
1	ASM ^d	1	24L, 24R, 25L, 25R	24L, 24R, 25L, 25R	VFR1	1977	1977	None
2	ASM	2	24R, 25L, 24L, 25R	24L, 25R	IFR1	1977	1977	None
3	ASM	3	24R, 25L	24L, 25R	IFR2	1977	1977	None
4	ASM	5	6R, 7L	24L, 25R	VFR1	1977	1977	None
5	ASM	6	6R, 7L	24L, 25R	IFR1	1977	1977	None
6	ASM	4	6L, 6R, 7L, 7R	6L, 6R, 7L, 7R	VFR1	1977	1977	None
7	ASM	1	24L, 24R, 25L, 25R	24L, 24R, 25L, 25R	VFR1	1982	1977	None
8	ASM	2	24R, 25L, 24L, 25R	24L, 25R	IFR1	1982	1977	None
9	ASM	4	6L, 6R, 7L, 7R	6L, 6R, 7L, 7R	VFR1	1982	1977	None
10	ASM	5	6R, 7L	24L, 25R	VFR1	1982	1977	None
11	ASM	1	24L, 24R, 25L, 25R	24L, 24R, 25L, 25R	VFR1	1982	1982	1982 ^e
12	ASM	2	24R, 25L	24L, 25R	IFR1	1982	1982	1982
13	ASM	1	24L, 24R, 25L, 25R	24L, 24R, 25L, 25R	VFR1	1982	1982	2, 3, 9 ^f
14	ASM	2	24R, 25L	24L, 25R	IFR1	1982	1982	2, 3, 9 ^f
15	ASM	5	6R, 7L	24L, 25R	VFR1	1982	1982	5, 7, 8 ^g
16	ASM	4	6L, 6R, 7L, 7R	6L, 6R, 7L, 7R	VFR1	1982	1982	5, 7, 8 ^g
17	ADM	n.a.	n.a.	n.a.	n.a.	1977	1977	None
Stage 2 Experiments								
18	ASM	1	24L, 24R, 25L, 25R	24L, 24R, 25L, 25R	VFR1	1982	1982	10 ⁱ
19	ASM	1	24L, 24R, 25L, 25R	24L, 24R, 25L, 25R	VFR1	1982	1982	11 ^j
20	ASM	1	24L, 24R, 25L, 25R	24L, 24R, 25L, 25R	VFR1	1982	1982	Terminal Expansion ^k
21	ASM	1	24L, 24R, 25L, 25R	24L, 24R, 25L, 25R	VFR1	1982	1982	Remote Terminal ^l
22	ASM	7	24L, 24R, 25L	24L, 24R, 25L	VFR1	1977	1977	Tunnel Construction
23	ASM	8	24R, 25L	24L, 25L	IFR1	1977	1977	Tunnel Construction
24	ASM	9	24R, 25R	24L, 25R	IFR1	1977	1977	Tunnel Construction
25	ASM	1	24L, 24R, 25L, 25R	24L, 24R, 25L, 25R	VFR1	1987	1987	Tunnel Construction
26	ASM	2	24R, 25L	24L, 25R	IFR1	1987	1987	Tunnel Construction
27	ADM	n.a.	n.a.	n.a.	n.a.	1982	1982	1982
28	ADM	n.a.	n.a.	n.a.	n.a.	1982	1982	None
29	ADM	n.a.	n.a.	n.a.	n.a.	1982	1977	1982
30	ADM	n.a.	n.a.	n.a.	n.a.	1982	1977	None
31	ADM	n.a.	n.a.	n.a.	n.a.	1987	1987	1987
32	ADM	n.a.	n.a.	n.a.	n.a.	1987	1987	None
33	ADM	n.a.	n.a.	n.a.	n.a.	1987	1977	1987
34	ADM	n.a.	n.a.	n.a.	n.a.	1987	1977	None

See Footnotes on following page.

n.a. = not applicable.

- a. Study cases (combinations of runway use and weather conditions) are defined in Figure III-1.
- b. FMA will describe impact of 1982 and post-1987 ATC systems on model inputs.
- c. Potential near-term improvements are identified in the Los Angeles International Airport Improvement Task Force Interim Report, and in Appendix B.
- d. Airfield Simulation Model.
- e. Task Force will establish packages of near-term improvements most likely to be implemented in 1982 and 1987 time frames.
- f. Improvement #2 is a high-speed taxiway off Runway 25L to the south. Improvement #3 is the strengthening of the Sepulveda Tunnel. Improvement #9 extends Runway 24R to 10,285 feet.
- g. Improvement #5 is a high-speed taxi exit off Runway 7. Improvement #7 is a high-speed taxi exit to Taxiway 47 from Runway 6R. Improvement #8 is a bypass area on the north side of Runway 7L.
- h. Annual Delay Model.
- i. Improvement #10 consists of a series of taxiway improvements identified in Appendix B.
- j. Improvement #11 contains temporary holding areas on present Taxiway 47 west of Satellites 3 and 4.
- k. Construction of Satellite 1 and International Terminal.
- l. Remote parking for 20 aircraft at west end of Airport.



◁ ARRIVAL AIRCRAFT
 ◀ DEPARTURE AIRCRAFT

Weather: VFR1--ceiling at least 2,500 feet and visibility at least 3 miles.

VFR2--ceiling of 1,000 feet and visibility of 3 miles.

IFR1--ceiling less than 1,000 feet and/or visibility less than 3 miles.

IFR2--IFR conditions that require special missed approach protection.

600' & 1 mile - spell out

Figure III-1

STUDY CASES
 Los Angeles International Airport
 Delay Improvement Study
 PMM&Co. September 1971

Two experiments (Experiments 11 through 12) are recommended to assess delays to aircraft in 1982 if an improved ATC system scenario is available and if various physical improvements are implemented.

To develop other experiments to estimate the impact of near-term improvements, the near-term improvement items identified in the Los Angeles Interim Report (and listed in Appendix B) were assessed. This assessment resulted in recommendations to perform simulation model experiments associated with the following improvement items:

- # 2 Provide high speed taxiway off of Runway 25L to the south
- # 3 Strengthen the Sepulveda Tunnel
- # 5 Provide high speed exit from Runway 7L
- # 7 Provide high speed exit from Runway 6R to taxiway 47
- # 8 Establish bypass area in the north side of Runway 7L
- # 9 Extend Runway 24R to 10,285 feet
- #10 Improve taxiways 47, 49, J, K, and F, and build a taxiway to connect taxiways 45 and 49
- #11 Build temporary holding areas on Taxiway 47

Two experiments (Experiments 13 and 14) are recommended to assess the delay impact of near-term improvements #2, #3, and #9. The two experiments combine all three improvements into a related improvement package and assess the benefits to be derived from balancing the operations on the north and south runway complexes. With these improvements, runway assignments can be made more closely dependent upon each aircraft's gate location and direction of flight.

Two experiments (Experiments 15 and 16) are recommended to test near-term improvements #5, #7, and #8. These improvements are grouped as a package and tested for night time operations (Experiment 15) and for east operations (Experiment 16).

Experiment 18 is recommended to test improvement #10, Improvement of taxiways. Experiment 19 is recommended to test near-term improvement #11, build temporary building areas on taxiway 47 west of Satellites 3 and 4.

Two experiments (Experiments 20 and 21) are recommended to test the effects of terminal building additions.

Experiment 20 is recommended to evaluate the addition of Satellite #1, the construction of an International terminal at the commuter terminal, and the associated realignment of airline gates. Experiment 21 is recommended to evaluate the benefit of having 20 remote aircraft parking pads at the west end of the airport for international flights.

Three experiments (Experiments 22, 23, and 24) are recommended to assess the delay impacts of runway closures of Runways 25L and 25R during the strengthening of the Sepulveda tunnel. Experiments 22 and 23 assess the impact of closure of Runway 25R during VFR1 and IFR1 conditions respectively. Experiment 24 assesses the impact of closure of Runway 25L during IFR1 conditions.

Two additional experiments (Experiments 25 and 26) are recommended to assess delays to aircraft in 1987 if an improved ATC system scenario is available and if various physical improvements are implemented.

Therefore, a total of 25 simulation model experiments are recommended:

- 6 1977 baseline experiments
- 4 1982 baseline experiments
- 2 1982 experiments for most likely scenarios
- 6 experiments to assess near-term improvements identified in the Interim Report.
- 5 additional experiments for terminal expansion and tunnel construction
- 2 1987 experiments for most likely scenarios

Annual Delay Model Experiments

Nine annual delay model experiments are recommended to compute annual delays to aircraft.

One baseline delay experiment is recommended to estimate annual average delay to aircraft for today's situation (Experiment 17).

Two additional experiments are recommended to cover the most likely scenario for two future time frames--1982 (Experiment 27) and 1987 (Experiment 31).

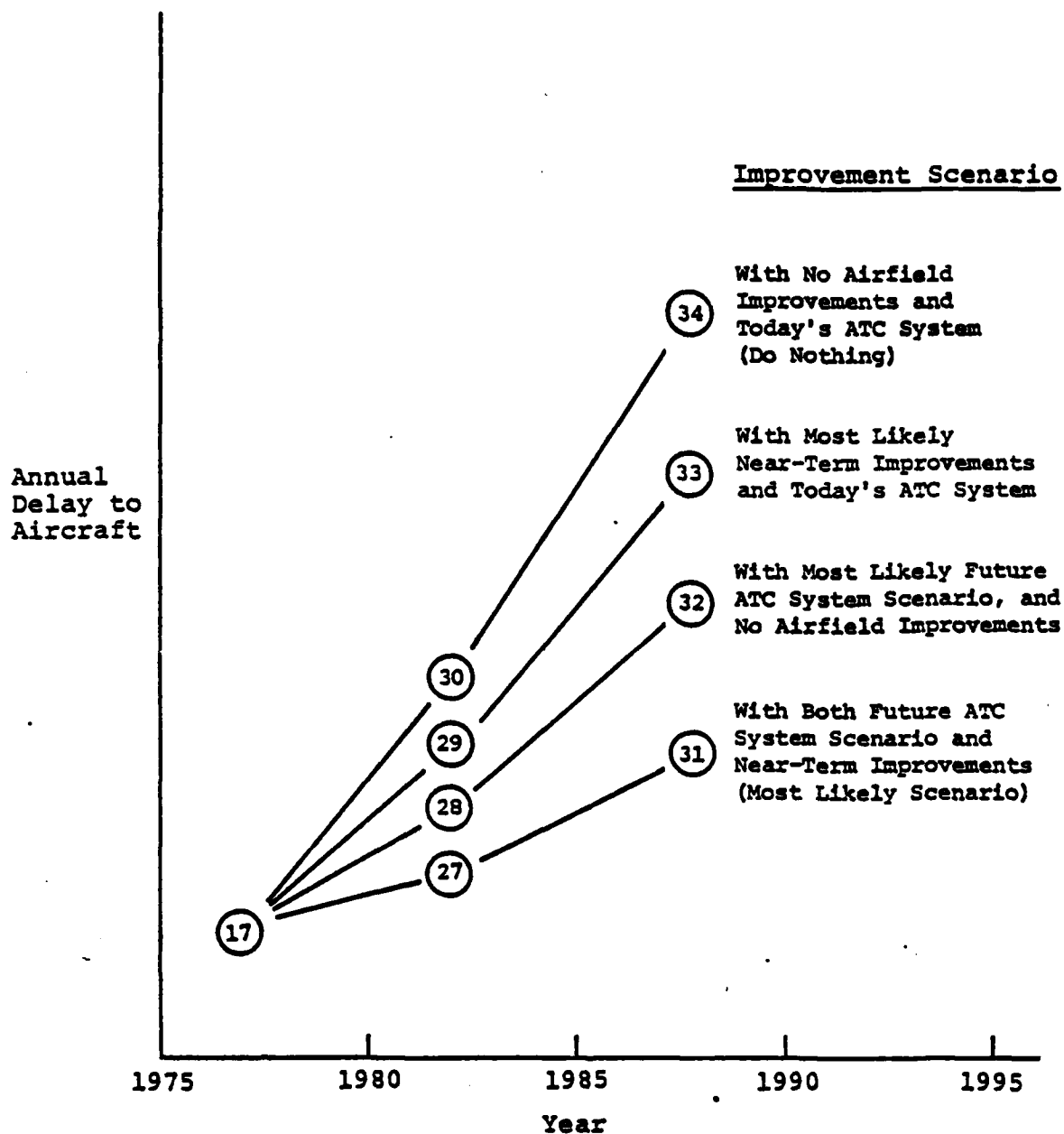
Six additional sensitivity experiments are recommended to assess the delays that may occur if the most likely scenario of combinations of near-term improvements and ATC systems is not implemented, three experiments in each of the 1982 and 1987 time frames. The three 1982 experiments are designed to assess:

- the absence of airfield improvements (Experiment 28)
- the absence of future ATC systems (Experiment 29), and
- the do-nothing situation (Experiment 30)

The three 1987 experiments (Experiments 32, 33, and 34) are designed to perform the same assessments in the longer time frame.

The interrelationship of these nine annual delay model experiments is illustrated in Figure III-2, which shows the variation of average annual aircraft delay with time. The variation is based on hypothetical results of the nine annual delay estimates.

The foregoing paragraphs describe 34 recommended delay experiments. Additional or alternative delay experiments may be considered by the Task Force. It is suggested that an experimental design subgroup meet to discuss the recommended experiments and to finalize those experiments to be performed.



Legend

(31) Delay experiment number

Figure III-2
 HYPOTHETICAL RESULTS OF NINE ANNUAL
 DELAY EXPERIMENTS
 Los Angeles International Airport
 III-10 Delay Improvement Study
 PMM&Co. September 1978

IV. DATA REQUIREMENTS

Data Needs for Model Runs

The airfield simulation model and the annual delay model are recommended to be run to perform the model calibration and to prepare the delay estimates. Each model run requires a set of input data that describes the conditions being investigated.

Input Data for Airfield Simulation Model. The 38 types of input data required to run the simulation model are described below:

a. Logistics

1. Title: A brief description of the model application.
2. Random Number Seeds: Each random number seed represents a daily set of variations of events. (The number of random number seeds is selected to achieve stochastic convergence of results.)
3. Start and Finish Times: The times when the run is to start and finish.
4. Print Options: Several options are available concerning level of detail of output, debugging statements, etc.
5. Airline Names: The two-letter codes for each airline included in the demand data (include dummy code for general aviation or military aircraft).
6. Processing Options: Several options are available concerning the way input data are processed, e.g., print input data only.
7. Truncation Limits: Applies to the limits of normal distribution used in the Monte Carlo sampling technique. Defined in terms of a number of standard deviations.

8. Time Switch: Permits variation of model inputs during a model run at a particular time. (Special care must be taken when using the time switch to avoid model operation inconsistencies.)

b. Airfield Physical Characteristics

9. Airfield Network: A description of the airfield in terms of a network of links and nodes.
10. Number of Runways: The number of runways.
11. Runway Identification: Their identifiers.
12. Departure Runway End Links: The taxiway link(s) that can be occupied by aircraft prior to being given departure clearance.
13. Runway Crossing Links: The taxiway link(s) that can be occupied by aircraft prior to crossing an active runway, together with clearance times to the crossing taxiway for arriving and departing aircraft.
14. Exit Taxiway Location: The distance from the threshold of each exit taxiway, by runway.
15. Holding Areas: Those sections of taxiways or apron that are used for storing arrival aircraft that are awaiting a gate.
16. Airline Gates: The gates belonging to each airline.
17. GA Basing Areas: The basing areas for general aviation aircraft.

c. ATC Procedures

18. Aircraft Separations: Mean and standard deviation of minimum separations for each aircraft pair class for arrival-arrival, departure-arrival, departure-departure, and arrival-departure sequences (for each runway and for pairs of dependent runways).

19. Route Data: Link sequence for routes from each exit taxiway to each gate and each gate to each departure runway. Also, link sequence for routes from each exit taxiway to each holding area and from each holding area to each gate.
20. Two-Way Path Data: Link sequence for those sections of taxiway used by aircraft that may be traveling in either direction.
21. Common Approach Path(s): Length of the common approach to each runway by aircraft class.
22. Vectoring Delays: Level of airborne delay (by fix) to arrival aircraft at which holding delays start to occur.
23. Departure Runway Queue Control: Queue lengths (by runway) above which aircraft may be diverted to a different departure runway.
24. Gate Hold Control: Queue lengths (by runway) above which aircraft may be held at gate.
25. Departure Airspace Constraints: Mean and standard deviation of effect of departure airspace constraints on delays, and percentage of departures affected.
26. Departure Queue Control: Departure queue lengths above which interarrival spacings will be increased to release departures.
27. Runway Crossing Delay Control: Delays to taxiing aircraft waiting to cross an active runway above which interarrival spacings will be increased to permit crossings.

d. Aircraft Operational Characteristics

28. Exit Taxiway Utilization: Distribution of exit taxiway usage by aircraft class.

29. Arrival Runway Occupancy Times: Data on runway occupancy times for different distances from runway threshold by aircraft class.
30. Touch-and-Go Runway Occupancy Times: Mean and standard deviation by aircraft class.
31. Departure Runway Occupancy Times: Mean and standard deviation by aircraft class.
32. Taxi Speeds: Aircraft taxiing speeds for each of six taxiway link-types.
33. Approach Speeds: Mean and standard deviation by aircraft class.
34. Gate Service Times: Mean and standard deviation by aircraft class.
35. Airspace Travel Times: Undelayed travel times from approach fix to threshold and from threshold to departure fix by aircraft class.
36. Runway Crossing Times: Time for taxiing aircraft to cross active runway.
37. Lateness Distribution: Distribution of deviations from scheduled arrival times to be used in conjunction with an airline schedule (if applicable).
38. Demand: Detailed list of aircraft, including scheduled arrival and departure times, aircraft class, desired arrival and departure runway and fixes, flight type, preferred gate assignment for air carrier aircraft, and basing area for general aviation.

Four classes of aircraft are used when defining the model inputs (Classes 1, 2, 3, and 4). Each aircraft using the airport is assigned to one of the four classes. The definitions of the aircraft classes should reflect the significant groupings of aircraft at the airport that have similar operating characteristics (e.g., approach speed).

In defining the classes, it is important to note that the simulation model gate logic assumes that an aircraft can use a gate for its class number or a lower class number.

Blank data forms that may be used to assemble key input data items (Nos. 9, 18, 19, 34, 35, 37, and 38) are presented in Appendix C.

Input Data for Annual Delay Model. Fifteen types of input data required to run the annual delay model are listed below.

1. Annual Demand: Number of annual operations.
2. Group Specification: Number of day groups (up to 7); week groups (up to 52); weather groups (up to 10); and runway uses (up to 10).
3. Weekly Traffic: Proportion of total annual traffic in one week of each week group.
4. Number of Weeks: In each group.
5. Daily Traffic: Proportion of weekly traffic in one day of each group.
6. Number of Days: In each day group.
7. Weather Group Demand Factors: Ratio of demand in each weather group to the demand in the first weather group. There are as many factors as weather categories.
8. Weather Occurrences: Proportion of occurrence of each weather group in any given week group (i.e., the sum of all weather group occurrences for any week group is 1.0).
9. Hourly Runway Capacity: Hourly runway capacities for each runway use and weather combination.
10. Runway Use Occurrences: Proportion of time each runway use will be operated in the different weather conditions.

11. Hourly Traffic: Proportion of daily traffic to be distributed to each of the 24 hours.
12. Demand Profile Factor: (The proportion of peak-hour traffic in the peak 15 minutes.) This factor can take one of six values: 25, 30, 35, 40, 45, and 50.
13. Runway Use Demand Factor: Ratio of demand for each runway use to the demand for the first runway use. There are as many factors as runway uses.
14. Aircraft Mix: Mix for each runway use and weather combination. The mix should be that used to compute the hourly runway capacity.
15. User-Specified Title: Identifying alpha-numeric name to be printed in the output.

Data Sources

Data required for model runs will be developed by the Task Force, with assistance from NAFEC and PMM&Co. Planned responsibilities and procedures for development of the data are described below under the following classifications:

- Airfield Simulation Model Calibration Data
- Revisions to Simulation Model Input Data for Delay Experiments
- Annual Delay Model Baseline Data
- Revisions to Annual Delay Model Input Data for Delay Experiments

Airfield Simulation Model Calibration Data. Model calibration is designed to make the model site-specific to the Los Angeles situation. The calibration effort involves a comparison of observed field data on aircraft flow rates, delays, and travel times with outputs from a simulation model run. The simulation model run requires a set of input data that reflects the operating conditions prevalent during the collection of the observed field data.

Therefore two types of data are needed for model calibration-- (1) model input data and (2) field data for comparison with model outputs. The three planned sources for these two types of data--the Task Force, Field Data, and NAFEC--are listed in Table IV-1.

- Data from the Task Force refers to information currently in the possession of or available to the Task Force. For example, estimates of the level of airborne delay to arrival aircraft at which holding starts to occur (Input No. 22) may be obtained from ATC personnel.
- Field data refers to information that will be obtained by the Task Force by field observation during a data collection activity. For example, the travel time for aircraft taxiing from gate to runway may be obtained by visual observation of the time the aircraft leaves its gate and the time that it reaches the runway. (Details of field data collection are given later in this chapter.)
- Data from NAFEC refers to information currently in the possession of or to be developed by NAFEC. For example, NAFEC will provide departure runway occupancy times based on the previously performed capacity analyses.

Revisions to Simulation Model Input Data for Delay Experiments. Each simulation model experiment described in Chapter III requires input data that describe the situation being examined. The data will be based on the model calibration data described above. Revisions will be made to the model calibration input data to reflect the conditions to be investigated in each delay experiment. The revisions may impact any of the 38 types of input.

All of the revisions to simulation model input data for delay experiments will be developed by the Task Force, with assistance from NAFEC, PMM&Co. and FAA Headquarters. No additional field data collection is anticipated.

Table IV-1
SOURCES OF DATA FOR
AIRFIELD SIMULATION MODEL CALIBRATION

Data Type	Source
<u>1 INPUT DATA</u>	
<u>a. Logistics</u>	
1 Title	NAFEC
2 Random number seeds	NAFEC
3 Start and finish times	Field Data
4 Print options	NAFEC
5 Airline names	NAFEC
6 Processing options	NAFEC
7 Truncation limits	NAFEC
8 Time switch	NAFEC
<u>b. Airfield Physical Characteristics</u>	
9 Airfield network	NAFEC
10 Number of runways	NAFEC
11 Runway identification	NAFEC
12 Departure runway and links	NAFEC
13 Runway crossing links	NAFEC
14 Exit taxiway location	NAFEC
15 Holding areas	Task Force <i>Jack Grehn</i>
16 Airline gates	Task Force
17 General aviation basing areas	Task Force
<u>c. ATC Procedures</u>	
18 Aircraft separations	Field Data
19 Route data	Task Force <i>JJ</i>
20 Two-way path data	Task Force <i>JJ</i>
21 Common approach paths	Task Force <i>JJ check</i>
22 Vectoring delays	Task Force
23 Departure runway queue control	Task Force
24 Gate hold control	Task Force
25 Departure airspace constraints	Task Force
26 Departure queue	Task Force
27 Runway crossing delay control	Task Force
<u>d. Aircraft Operational Characteristics</u>	
28 Exit taxiway utilization	Task Force
29 Arrival runway occupancy times	Task Force <i>Non Cap. & NAFEC</i>
30 Touch-and-go runway occupancy times	Task Force <i>PMN & Field Data</i>
31 Departure runway occupancy times	NAFEC
32 Taxi speeds	Field Data
33 Approach speeds	Field Data
34 Gate service times	Task Force <i>ATA</i>
35 Airspace travel times	Field Data
36 Runway crossing times	Field Data
37 Lateness distribution	Task Force <i>ATA</i>
38 Demand	Field Data <i>ATA for experiments</i>
<u>2 OUTPUT DATA</u>	
A Flow rates	Field Data
B Delays	Field Data
C Travel Times	Field Data

Have Tony look into these during data collection

NAFEC develop values & coordinate with JJ. - Develop values & have JJ review.

Each delay experiment involves some or all of the following types of changes from the model calibration situation:

- Study Case--the runways in use and the weather condition may differ
- Demand--the number of aircraft operations in each hour may differ
- Near-Term Improvements--improvement items may be added that impact aircraft operations
- ATC System Scenarios--a future ATC system may be added that changes ATC procedures

For example, from Table III-1 it can be seen that Experiment 21 is designed to investigate the potential benefits of a remote parking position for international arrivals. To develop the input data for this experiment, the input data for model calibration should be revised as follows.

The Study Case is changed from the calibration condition to a special study case that permits arrivals to park at the remote location. To correspond with this change, a number of model inputs must be revised--for example, the arrival taxiing routes must now connect the runways with the remote parking areas.

The Demand is changed from the calibration demand level to a level that reflects 1982 conditions. A revised schedule must be prepared that reflects forecasts of traffic increases and changes in aircraft mix that represent the Task Force view of the 1982 time period.

The ATC System Scenario that is considered most likely to be implemented in the 1982 time period is defined. Model inputs are then revised to reflect the improvement package--for example, aircraft separations may be reduced to reflect the presence of a wake vortex advisory system.

Annual Delay Model Baseline Data. Delay Experiment 17 calls for an estimate of average annual delay to aircraft under 1977 baseline conditions.

The planned sources for the 15 types of data required for the baseline run are shown in Table IV-2. No additional field data collection is anticipated. However, discussion of some of the data types will be required to help define the input definition. For example, definition of the occurrence of runway uses may involve a comparison of Task Force historical data on runway uses with data on crosswinds, ceiling, and visibility.

One of the major input data items is the hourly runway capacity associated with each baseline study case. Some of this capacity information can be derived directly from the previous capacity work of the Task Force. Additional capacity information will be required, and the hourly runway capacity model (that was previously used for Los Angeles) will be used to provide the additional capacity information. A description of this capacity model is included in Appendix A.

Revisions to Annual Delay Model Input Data for Delay Experiments. Each annual delay model experiment recommended in Chapter III requires input data that describe the situation being examined. The 1977 baseline delay experiment is described above.

Input data for the remaining experiments will be based on the input data developed for the 1977 baseline delay experiment. Revisions will be made to the baseline input data to reflect the conditions to be investigated in each delay experiment. The revisions may impact any of the 15 types of input.

All of the revisions to annual delay model input data for delay experiments will be developed by the Task Force, with assistance from NAFEC, PMM&Co., and FAA Headquarters. No additional field data are anticipated.

The annual delay model experiments involve the following types of changes in input data from the baseline condition:

- Demand
- Near-Term Improvements
- ATC System Scenarios

In many cases, these types of changes in input data are similar to the changes for the simulation model described previously.

Table IV-2

SOURCES OF BASELINE DATA FOR ANNUAL DELAY MODEL

Data Type	Source
1 Annual demand	Task Force <i>Ja 41977 from town</i>
2 Group specification	NAFEC <i>Count & PMS</i>
3 Weekly traffic	Task Force <i>needed in 1 week</i>
4 Number of weeks in each group	NAFEC
5 Daily traffic	Task Force <i>Send to J. V.</i>
6 Number of days in each group	NAFEC
7 Weather group demand factors	Task Force —
8 Weather Occurrences	NAFEC
9 Hourly runway capacity	NAFEC
10 Runway use occurrences	Task Force —
11 Hourly traffic	Task Force —
12 Demand profile factor	NAFEC
13 Runway use demand factor	NAFEC
14 Aircraft mix	NAFEC
15 User-specified title	NAFEC

For example, the 1982 do-nothing experiment (Experiment 30) requires a change in the demand from the 1977 baseline demand and aircraft mix to the most likely 1982 demand and aircraft mix. Any corresponding changes in runway capacity are also required. Other inputs would remain unchanged, i.e., the same as the 1977 baseline.

Field Data Collection Plan

Field data are to be collected to provide input and output data for simulation model calibration. The major types of data that will be obtained are:

a. Inputs

- Airspace travel times
- Taxi times and speeds
- Demand
- Aircraft separations

b. Outputs

- Flow rates
- Delays
- Travel times

To obtain these data, field data are planned to be collected during the week of Monday, September 25, 1978. Data will be collected during peak periods on five consecutive weekdays. In the event of exceptional weather conditions or other contingencies, the data collection may extend into the following week.

The data to be obtained are the time that each aircraft in the observation period passes points on the airfield and in the airspace, as follows:

Arrival Aircraft

Arrival Fix
Runway Threshold
Onto Ramp

Departing Aircraft

Off Ramp
Departure Roll

In addition, sample data will be obtained for the following:

- Airspace and taxiway routes
- Undelayed travel times
- Exit utilization and runway occupancy times
- Runway crossing times

Visual observations will be made from vantage points in the ATC Tower (or other suitable locations) and by monitoring appropriate radar scopes. The data will be recorded manually on data forms and then reduced by NAFEC personnel using NAFEC data reduction computer programs.

The number of data collection personnel required will depend on the skills of the personnel and the available locations for observing aircraft operations. A preliminary assessment performed by NAFEC personnel indicates the potential need for 7 persons, plus the NAFEC supervisor and 1 clerical assistant to help collate the data. Potential assignments for the personnel are:

<u>Personnel Number</u>	<u>Data Collection Assignment</u>
1	Arrival fix times (watching ARTS scope in TRACON)
2 & 3	Arrival runway threshold time (observing from tower, and tuned to local control)
4	Departure roll times (observing from tower, and tuned to local control)
5 & 6	Ramp on and off times (observing from tower and tuned to ground control)
7	Backup for data collection and taking samples of aircraft routes, etc.

The data collection supervisor is responsible for noting details of airport operations (weather, runway use, special events, problems, etc.) and for assuring the completeness, clarity, and accuracy of the data collection forms. The supervisor ensures the continued availability of controller voice tapes (approach, local, and ground control) to assist in clarifying any uncertainties that arise during data reduction, and obtains the ARTS tapes, and the FAA Aircraft Delay Report (ADR) for the data collection period. The supervisor also arranges to receive the tower counts, PMS reports, and weather observations for the data collection period.

At the end of each data collection period, the supervisor checks the forms for completeness and accuracy and then organizes the collation of the data onto two sets of forms--one set each for arrivals and departures--that will show the time that each aircraft passes the fix, the runway, and the ramp. Sample data collation forms are shown in Figures IV-1 and IV-2. The form shown in Figure IV-1 is used for recording arrival aircraft information. Each observer of arrival aircraft records for each aircraft, in order, the aircraft identification (e.g., UA 390), the aircraft type (e.g., B727), and the aircraft class (A, B, C, or D). The observer also records the identification of the station (fix, runway, or gate) and the time (GMT, to the nearest second) the aircraft passes or reaches the station. A similar procedure is used for departure aircraft. Departure data are recorded on the form shown in Figure IV-2.

DATA COLLATION FORM - ARRIVALS

AIRCRAFT IDENT.		AC TYPE	CLASS	APR. FIX I.D.	ARRIVAL FIX TIME	R/W I.D.	RUNWAY THRESHOLD TIME	GATE I.D.	ARRIVAL GATE TIME
1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100
101	102	103	104	105	106	107	108	109	110
111	112	113	114	115	116	117	118	119	120
121	122	123	124	125	126	127	128	129	130
131	132	133	134	135	136	137	138	139	140
141	142	143	144	145	146	147	148	149	150
151	152	153	154	155	156	157	158	159	160
161	162	163	164	165	166	167	168	169	170
171	172	173	174	175	176	177	178	179	180
181	182	183	184	185	186	187	188	189	190
191	192	193	194	195	196	197	198	199	200
201	202	203	204	205	206	207	208	209	210
211	212	213	214	215	216	217	218	219	220
221	222	223	224	225	226	227	228	229	230
231	232	233	234	235	236	237	238	239	240
241	242	243	244	245	246	247	248	249	250
251	252	253	254	255	256	257	258	259	260
261	262	263	264	265	266	267	268	269	270
271	272	273	274	275	276	277	278	279	280
281	282	283	284	285	286	287	288	289	290
291	292	293	294	295	296	297	298	299	300
301	302	303	304	305	306	307	308	309	310
311	312	313	314	315	316	317	318	319	320
321	322	323	324	325	326	327	328	329	330
331	332	333	334	335	336	337	338	339	340
341	342	343	344	345	346	347	348	349	350
351	352	353	354	355	356	357	358	359	360
361	362	363	364	365	366	367	368	369	370
371	372	373	374	375	376	377	378	379	380
381	382	383	384	385	386	387	388	389	390
391	392	393	394	395	396	397	398	399	400
401	402	403	404	405	406	407	408	409	410
411	412	413	414	415	416	417	418	419	420
421	422	423	424	425	426	427	428	429	430
431	432	433	434	435	436	437	438	439	440
441	442	443	444	445	446	447	448	449	450
451	452	453	454	455	456	457	458	459	460
461	462	463	464	465	466	467	468	469	470
471	472	473	474	475	476	477	478	479	480
481	482	483	484	485	486	487	488	489	490
491	492	493	494	495	496	497	498	499	500
501	502	503	504	505	506	507	508	509	510
511	512	513	514	515	516	517	518	519	520
521	522	523	524	525	526	527	528	529	530
531	532	533	534	535	536	537	538	539	540
541	542	543	544	545	546	547	548	549	550
551	552	553	554	555	556	557	558	559	560
561	562	563	564	565	566	567	568	569	570
571	572	573	574	575	576	577	578	579	580
581	582	583	584	585	586	587	588	589	590
591	592	593	594	595	596	597	598	599	600
601	602	603	604	605	606	607	608	609	610
611	612	613	614	615	616	617	618	619	620
621	622	623	624	625	626	627	628	629	630
631	632	633	634	635	636	637	638	639	640
641	642	643	644	645	646	647	648	649	650
651	652	653	654	655	656	657	658	659	660
661	662	663	664	665	666	667	668	669	670
671	672	673	674	675	676	677	678	679	680
681	682	683	684	685	686	687	688	689	690
691	692	693	694	695	696	697	698	699	700
701	702	703	704	705	706	707	708	709	710
711	712	713	714	715	716	717	718	719	720
721	722	723	724	725	726	727	728	729	730
731	732	733	734	735	736	737	738	739	740
741	742	743	744	745	746	747	748	749	750
751	752	753	754	755	756	757	758	759	760
761	762	763	764	765	766	767	768	769	770
771	772	773	774	775	776	777	778	779	780
781	782	783	784	785	786	787	788	789	790
791	792	793	794	795	796	797	798	799	800
801	802	803	804	805	806	807	808	809	810
811	812	813	814	815	816	817	818	819	820
821	822	823	824	825	826	827	828	829	830
831	832	833	834	835	836	837	838	839	840
841	842	843	844	845	846	847	848	849	850
851	852	853	854	855	856	857	858	859	860
861	862	863	864	865	866	867	868	869	870
871	872	873	874	875	876	877	878	879	880
881	882	883	884	885	886	887	888	889	890
891	892	893	894	895	896	897	898	899	900
901	902	903	904	905	906	907	908	909	910
911	912	913	914	915	916	917	918	919	920
921	922	923	924	925	926	927	928	929	930
931	932	933	934	935	936	937	938	939	940
941	942	943	944	945	946	947	948	949	950
951	952	953	954	955	956	957	958	959	960
961	962	963	964	965	966	967	968	969	970
971	972	973	974	975	976	977	978	979	980
981	982	983	984	985	986	987	988	989	990
991	992	993	994	995	996	997	998	999	1000

**Number of hours per gate may vary slightly

Figure IV-1
ARRIVAL DATA COLLATION FORM
Los Angeles International Airport
Delay Improvement Study
PMM&Co. September 1978

The collated field data are then transferred to NAFEC for data reduction to produce the desired model inputs and outputs. After data reduction, the model inputs and outputs are used in the model calibration. It is planned that the data will be reviewed by the Task Force during the second Task Force meeting prior to use of the data for model calibration.

Appendix A

MODELS AVAILABLE TO TASK FORCE

This appendix provides an overview of the models that are available to assist the Task Force in computing delays to aircraft.

The PMM&Co. airfield simulation model is available for computations of hourly and/or daily delays to aircraft. The simulation model also computes aircraft flow rates and travel times.

The annual delay model is available for computations of annual delays to aircraft. The annual delay model also computes distributions of average aircraft delays.

A number of additional models are also available to the Task Force, including (1) a weather model to analyze weather occurrence at an airport based on raw airport climatological data from the National Weather Records Center, and (2) an analytical runway capacity model that computes estimates of hourly runway capacity.

I. AIRFIELD SIMULATION MODEL

The PMM&Co. airfield simulation model contains a set of logic statements that describe the significant movements performed by aircraft on the airfield and in the adjacent airspace. The simulation model operates by tracing the path of each aircraft through space and time on the airfield and adjacent airspace. The airfield is represented by a series of links and nodes depicting the paths that an aircraft could follow. The traces of the paths of all aircraft are made by continually advancing clock time and recording the new location of the aircraft. The records of aircraft movement are then processed by the model to produce desired outputs including delays, travel times, and flow rates.

The PMM&Co. airfield simulation model is a critical events model that employs Monte Carlo sampling techniques. Variable time increments are used as the time flow mechanism; clock time is advanced by the amount necessary to cause the next most imminent (i.e., critical) event to take place. Running time for the model, therefore, depends on the levels of aircraft demand (and the size of the airfield) for any particular application.

The use of Monte Carlo sampling techniques permits the day-to-day variations encountered in real life to be simulated by the model. Certain of the model parameters are stochastic (time variant and random) in nature. For example, arrival aircraft approach speeds will vary from day to day for any given aircraft depending on such factors as payload, wind, and pilot technique. The distribution of these variations can be approximated by the normal distribution. The model assigns arrival aircraft approach speeds by sampling values from a normal distribution with mean and standard deviation specified by the user. Other stochastic model parameters are:

- Arrival/arrival separations
- Departure/arrival separations
- Arrival/departure separations
- Departure/departure separations
- Arrival runway occupancy time
- Touch-and-go runway occupancy time
- Departure runway occupancy time

- Exit taxiway choice
- Gate service time
- Arrival aircraft deviation from schedule

Because of the modular structure of the model, analysis of the total airfield or its individual components can be performed by manipulation of the model inputs. This approach is more flexible and efficient than having separate submodels for the individual components and a composite model for the total airfield.

In the following paragraphs, further details of simulation model logic are described as follows:

- Movement of aircraft--description of the progress of an aircraft through the airfield system.
- Runway and airspace operations--description of ATC algorithms that separate pairs of aircraft on the runways and in the airspace.
- Taxiing operations--description of model logic that processes aircraft on taxiways.
- Gate operations--description of model logic that processes aircraft in the apron-gate area.

Movement of Aircraft

Arrival aircraft commence at the appropriate arrival fixes in accordance with generated demand inputs. For each arrival aircraft, approach speeds are assigned from an empirical distribution according to the class of the aircraft. For each arrival pair, interarrival times, final approach speeds, and wake turbulence characteristics are checked so that sufficient separation exists on the common approach path. (The length of the common approach path is specified by the user.) As each aircraft arrives over the threshold, an exit taxiway and associated runway occupancy time are assigned to the aircraft.

The aircraft's routing to the gate or basing area is established in the following manner. As an air carrier aircraft exits the runway, a check is made on the availability of a gate of the correct size belonging to the airline under

consideration. In the event a gate is not available, the aircraft is routed to a holding area where further checks on gate availability are made. In the case of general aviation or military aircraft, the aircraft's route to the basing area is assigned on the basis of the exit taxiway used and the location of the basing area.

Once an aircraft's route to the gate or basing area has been established, the aircraft is moved along its route from link-to-link on the airfield network. Checks are made at each link to determine whether the next link on the route is available or occupied by another aircraft. If the next link is occupied, the aircraft is not moved until the link is vacated. Thus, the travel time is increased for the particular aircraft, and delay is incurred.

When the aircraft reaches its gate, a gate occupancy time is assigned from empirical distributions and is added to the gate arrival time. This information, when compared with the scheduled departure time, determines the earliest time when the aircraft could leave the gate. The empirical distributions for gate occupancy time may reflect the typical bunching of the schedules of air carrier departures. When an aircraft is ready to leave the gate, a check is made to ensure that the ramp area is clear for push-back. The route to the departure runway is determined by the aircraft's basing area or gate location, the aircraft class, and the departure runways in use at that particular time.

In the case of general aviation or military aircraft, when the aircraft reaches the basing area, it is assumed to be parked and to have left the system. This assumption is necessary because of the unstructured nature of general aviation or military operations on the apron. The flow of aircraft from the basing area is generated from the demand inputs by producing an expected departure time from the basing area for each general aviation aircraft. The route to the departure runway is established by the location of the basing area and the departure runways in use.

When an aircraft reaches the threshold of the departure runway, compliance with ATC procedures is checked and confirmed before the aircraft is cleared for takeoff. The following checks are made:

- Has the previous dependent arrival cleared the runway?
- Is there sufficient separation from the next incoming dependent arrival?

- Is there sufficient separation from the previous dependent departure?

If all of these checks are positive, the aircraft is cleared for takeoff.

Runway and Airspace Operations

An ATC algorithm allows the specification of separations between aircraft on the same runway and on dependent runways. These separations are defined for an arrival following an arrival, a departure following an arrival, a departure following a departure, and an arrival following a departure. For arrivals or departures on each runway, the model checks that sufficient separation exists between the aircraft under consideration and any other aircraft operation on the same runway or any dependent runway. In determining the time separation between a pair of successive arrival aircraft at the runway threshold, the model takes into account:

1. The required air traffic control separation for the aircraft pair.
2. The final approach velocity of each aircraft.
 - a. If the trail aircraft is faster than the lead aircraft, the required arrival separation is assured at the runway threshold.
 - b. If the trail aircraft is slower than the lead aircraft, the required arrival separations are set up at the beginning of the common approach path. The amount of time the trail aircraft falls behind is included in the time separation over threshold for the aircraft pair.
3. Runway occupancy. Only one aircraft is permitted to occupy the runway at any given time.

The model determines a time separation between a pair of successive departure aircraft which takes into account the required air traffic control separation by aircraft pair. The model will permit a departure to roll on a runway (thus

interweaving arrivals and departures) when all of the following conditions have been fulfilled:

1. The previous arrival aircraft has exited.
2. When the departure begins to roll, the next arrival is far enough from the threshold for the departure to clear the runway before the arrival is over its threshold.
3. Sufficient separation from the previous departure exists.

For pairs of intersecting runways, the user must also input arrival-departure separations so the model checks that the arrival aircraft has cleared the intersection before a departure that is being cleared on the intersecting runway.

Several special ATC features are incorporated into the simulation model logic. One ATC feature included in the model increases arrival aircraft spacings on final approach to allow departure queues to be dissipated. The length of the departure queue (number of aircraft) at which the interarrival spacing is increased and the desired interarrival spacing (minutes) must be specified.

Another ATC feature included in the model searches departure runways for congestion before assigning a departure runway to an aircraft leaving its gate. A runway is selected that minimizes delay. If runway congestion is too heavy, the aircraft is held on the gate until the congestion reduces.

Taxiing Operations. The normal operation of the model moves aircraft from link to link on a predetermined path which is defined in terms of a series of links. The model performs a check to ensure that the next link on the path is not occupied by another aircraft before moving on to the link. It is assumed in the logic that the taxiway is used by aircraft moving in the same direction at all times, unless the user specifies to the contrary.

Taxiways on which aircraft may taxi in both directions are defined as two-way taxiways. These taxiways, which are defined by the user, may occur at several places on the airfield and are often found between pier fingers at a terminal building. The model checks aircraft movements to determine if the aircraft is about to enter a two-way path. In the event that an aircraft is about to enter a two-way path, the model then checks along the path to determine if there

are other aircraft on the path that may be moving toward a potential conflict. If a potential conflict exists, the aircraft for which the check is being made is delayed until the conflict condition no longer exists.

If an aircraft is about to taxi across an active runway, the model performs certain checks in accordance with ATC procedures to determine if it is safe for the aircraft to cross. Priority is always given to aircraft operating on the runway.

Gate Operations. Once a gate is assigned to an arriving air carrier aircraft, the model moves the aircraft from link to link on the network to the gate, observing a first-come-first served rule in the event of conflicts (except for taxiways across active runways). For those airfields having terminal buildings with pier fingers, a "two-way path" will often serve the gates between any two pier fingers. Thus, prior to entering the two-way path, the model will check for aircraft moving either toward or away from a particular gate on the path. In the event an aircraft is moving on the path toward a gate (i.e., away from the arrival aircraft for which the check is being performed), the model permits the arrival aircraft to taxi on the path toward its gate in "platoon fashion" similar to real-life operations. If an aircraft is taxiing from the gate or is in the process of pushing back, the arrival aircraft is held until the departing aircraft is clear of the two-way path.

When the model detects that an aircraft is ready to push back from the gate, a check is performed to see if the aircraft will push back onto a two-way path. If it will push back onto a two-way path, the model then checks for aircraft on the two-way path and permits "platooning" in a similar fashion as described for arrivals. If there is an aircraft taxiing toward the area which the departing aircraft will occupy during push-back, the aircraft is delayed on the gate until the arrival aircraft has cleared the area in question.

Procedure for Application of Model

The following is a typical procedure for applying the simulation model to evaluate aspects of airfield operations:

- Establish the conditions under which the application will be performed.

- Visit site to obtain first-hand familiarization with airfield operations.
- Assemble input data from (a) discussions with ATC, airport sponsor, and airline personnel; (b) historical data; and (c) field data collection as necessary. The preprocessor models should be used to prepare demand and routing data in machine compatible format.
- Coordinate input data with ATC, airport sponsor, and airline personnel.
- Load input data and use output options that permit input data to be reviewed before execution. Correct as necessary.
- Perform trial model run using one random number seed, with all diagnostic print options functioning, to check that the model is operating correctly for the input data that is being used. Correct as necessary.
- After confidence in model inputs has been established, suppress diagnostic print options before making the model runs for evaluation of airfield improvements.
- Determine level of output detail required for evaluation and specify appropriate print options.
- Perform model runs.
- Use postprocessor models as required to develop detailed statistical information on aircraft delays.

Inputs

The airfield simulation model was developed to be applicable to the range of airfield configurations currently in existence and to those configurations that are likely to evolve in the future. Consequently, the model does not contain any airport-specific or aircraft-class-specific data; all data are input.

Thus, the model may be applied to airfields ranging from a nontower general aviation field to an airfield with the complexity of Chicago O'Hare International Airport. It should be noted, however, that simulation model application is relatively expensive because of the model's complexity and the volume of input data required to run it. Therefore, the model is most often applied at airports with more complex airfield layouts that experience significant aircraft delays.

The 38 types of input data required to run the simulation model are listed below:

a. Logistics

1. Title: A brief description of the model application.
2. Random Number Seeds: Each random number seed represents a daily set of variations of events. (The number of random number seeds is selected to achieve stochastic convergence of results.)
3. Start and Finish Times: The times when the run is to start and finish.
4. Print Options: Several options are available concerning level of detail of output, debugging statements, etc.
5. Airline Names: The two-letter codes for each airline included in the demand data (include dummy code for general aviation or military aircraft).
6. Processing Options: Several options are available concerning the way input data are processed, e.g., print input data only.
7. Truncation Limits: Applies to the limits or normal distribution used in the Monte Carlo sampling technique. Defined in terms of a number of standard deviations.
8. Time Switch: Permits variation of model inputs during a model run at a particular time. (Special care must be taken

when using the time switch to avoid model operation inconsistencies.)

b. Airfield Physical Characteristics

9. Airfield Network: A description of the airfield in terms of a network of links and nodes.
10. Number of Runways: The number of runways.
11. Runway Identification: Their identifiers.
12. Departure Runway End Links: The taxiway link(s) that can be occupied by aircraft prior to being given departure clearance.
13. Runway Crossing Links: The taxiway link(s) that can be occupied by aircraft prior to crossing an active runway, together with clearance times to the crossing taxiway for arriving and departing aircraft.
14. Exit Taxiway Location: The distance from the threshold of each exit taxiway, by runway.
15. Holding Areas: Those sections of taxiways or apron that are used for storing arrival aircraft that are awaiting a gate.
16. Airline Gates: The gates belonging to each airline.
17. GA Basing Areas: The basing areas for general aviation aircraft.

c. ATC Procedures

18. Aircraft Separations: Mean and standard deviation of minimum separations for each aircraft pair class for arrival-arrival, departure-arrival, departure-departure, and arrival-departure sequences (for each runway and for pairs of dependent runways).
19. Route Data: Link sequence for routes from each exit taxiway to each gate and each gate to each departure runway. Also, link

sequence for routes from each exit taxiway to each holding area and from each holding area to each gate.

20. Two-Way Path Data: Link sequence for those sections of taxiway used by aircraft that may be traveling in either direction.

21. Common Approach Path(s): Length of the common approach to each runway by aircraft class.

ONTARIO = 4 MINS
VENTURA = 4 MINS
FILLMORE = 5 MINS
Seal Beach = 3 MINS.

22. Vectoring Delays: Level of airborne delay (by fix) to arrival aircraft at which holding delays start to occur.

23. Departure Runway Queue Control: Queue lengths (by runway) above which aircraft may be diverted to a different departure runway.

Use (slow 24") + 1
to keep from happening
Delays reach 10 mins at
runway ~ 6 to 8 A/C

24. Gate Hold Control: Queue lengths (by runway) above which aircraft may be diverted to a different departure runway.

In such periods
50%
 $\bar{x} = 5 \text{ mins.}$
 $\sigma = ?$

25. Departure Airspace Constraints: Mean and standard deviation of effect of departure airspace constraints on delays, and percentage of departures affected.

More arrivals to 24 on VFR.
on IFR this would occur.
Add 1 to 2 miles to each arrival.
10 to 12 A/C

26. Departure Queue Control: Departure queue lengths above which interarrival spacings will be increased to release departures.

Never occurred. Use
arbitrarily large # - say 10

27. Runway Crossing Delay Control: Delays to taxiing aircraft waiting to cross an active runway above which interarrival spacings will be increased to permit crossings.

d. Aircraft Operational Characteristics

28. Exit Taxiway Utilization: Distribution of exit taxiway usage by aircraft class.

29. Arrival Runway Occupancy Times: Data on runway occupancy times for different distances from runway threshold by aircraft class.

30. Touch-and-Go Runway Occupancy Times: Mean and standard deviation by aircraft class.
31. Departure Runway Occupancy Times: Mean and standard deviation by aircraft class.
32. Taxi Speeds: Aircraft taxiing speeds for each of six taxiway link-types.
33. Approach Speeds: Mean and standard deviation by aircraft class.
34. Gate Service Times: Mean and standard deviation by aircraft class.
35. Airspace Travel Times: Undelayed travel times from approach fix to threshold and from threshold to departure fix by aircraft class.
36. Runway Crossing Times: Time for taxiing aircraft to cross active runway.
37. Lateness Distribution: Distribution of deviations from scheduled arrival times to be used in conjunction with an airline schedule (if applicable).
38. Demand: Detailed list of aircraft including scheduled arrival and departure times, aircraft class, desired arrival and departure runway and fixes, flight type, preferred gate assignment for air carrier aircraft, and basing area for general aviation.

Four classes of aircraft are used when defining the model inputs (Classes 1, 2, 3 and 4). Each aircraft using the airport is assigned to one of the four classes. The definitions of the aircraft classes should reflect the significant groupings of aircraft at the airport that have similar operating characteristics (e.g., approach speed).

In defining the classes, it is important to note that the simulation model gate logic assumes that an aircraft can use a gate for its class number or a lower class number.

At the beginning of each run, the model assumes that there are no aircraft on the airfield. Aircraft are generated at

various locations on the airfield and in the adjacent air-space according to the demand schedule. To obtain relevant data for the time period being simulated, it is recommended that preloading be used. Preloading may be accomplished in one of two ways:

1. Start the simulation run approximately one hour ahead of the period of interest, using appropriate demand levels for that hour, or
2. Include in the demand schedule the aircraft that may be parked at the various airline gates at the beginning of the period of interest.

The first alternative is normally preferred if the period of interest being simulated is relatively short, i.e., one or two hours. If the period being simulated is greater than two hours, then the second alternative may be used.

Tests on the convergence of the model's stochastic parameters have indicated that it is normally desirable to use at least ten random number seeds when making a model run. Ten random number seeds, in effect, simulate the day-to-day variations of aircraft operations on ten days, for the period of the day under consideration.

Outputs

The primary outputs from the delay model are aircraft delays, travel times, and flow rates. In addition, the locations of aircraft delays are shown and departure runway queuing statistics are produced. The model outputs may be obtained in two levels of detail.

Summary Output. The summary output, which is automatically produced by the program together with a listing of the output data, contains the following information for each hour of the model run.

- Flow rates on runways, taxiways, and gates by aircraft class for arrival and departure aircraft.
- Delays (in minutes) for arrival and departure aircraft. For arrival aircraft, air delays are broken down into holding and

vectoring delays by approach fix and by runway, while ground delays are identified as taxi-in, runway crossing, and gate delays. For departure aircraft, ground delays are broken down into gate, taxi-out, runway crossing, and runway delays; departure gate delays (gate holds) and runway delays are broken down by cause (i.e., runway congestion and airspace congestion).

- Travel times (in minutes) for arrival and departure aircraft are given by fix, runway, and aircraft class.
- In addition to the summary information noted above, delays are provided for individual arrival and departure aircraft and for the location of those delays, (i.e., by link number). It is not meaningful to provide these data as average values over a number of random number seeds. Therefore, individual aircraft delays and link delays are provided for the last random number seed specified in the input data.

Detailed Output. The detailed output is a time-ordered record of the movements of individual aircraft as they move from link to link in the network. The information contained in the detailed output for each individual aircraft movement includes the following:

- Aircraft identification number
- Aircraft state
- Aircraft class
- Gate assignment (where applicable)
- Time over threshold (for arrival)
- Gate service time (where applicable)
- Gate departure time
- Simulation clock time
- Location of aircraft

All times are given in hours, minutes, and seconds except for times included in error messages and diagnostics which are given in minutes.

In addition to this detailed information, the number of aircraft in the queue for a departure runway is printed out each time an aircraft joins the queue and each time an aircraft is given clearance for takeoff. The information contained in this detailed output permits the user to follow the movement of individual aircraft and identify the cause(s) of the delay that an aircraft may experience.

II. ANNUAL DELAY AGGREGATION MODEL

Annual delay is made up of the sum of the individual aircraft delays that occur in each hour of the 365 days of the year. The annual delay aggregation model is an analytical model that takes information on airfield demand and capacity, computes hourly and daily delay, and aggregates daily delays to compute total annual delay, average delay per aircraft, and the distribution of delays.

The annual delay aggregation model computes hourly delays for a number of conditions that are representative of the seasonal and daily variations in demand, weather, runway use, and capacity.

The model assumes that the variations in demand over the year can be characterized by a number of representative daily demands. The number of representative daily demands used in an analysis for a particular airport depends on (1) the variability of daily and hourly demands through the year, and (2) the desired level of refinement in estimating annual delay. The model is capable of accommodating up to 365 daily demands, if desired or necessary.

The model converts annual demand into representative hourly demands using three demand distributions:

- Week-group distribution of demand
- Day-group distribution of demand
- Hourly distribution of demand

A week group is a set of weeks that have similar demand and weather characteristics. The week-group distribution of demand provides the proportion of annual demand that occurs in each week of a week group.

A day group is a set of days within a week that have similar demand characteristics. The day-group distribution of demand provides the proportion of weekly demand that occurs in each day of a day group.

The hourly distribution of demand provides the proportion of daily demand that occurs in each hour of the day.

The occurrence of different weather conditions and runway uses, and the hourly runway capacities corresponding to these occurrences, are provided as input to the model. These inputs are used to determine hourly demand and capacity.

Hourly delays are calculated for each hour of the year using delay curves built into the model. The average delay per operation for the year is computed by aggregating these hourly delays.

The three major steps in the model's calculation process are summarized as follows:

1. Determine each representative daily demand as follows:
 - a. Identify annual demand
 - b. Estimate demand for each week group
 - c. Estimate daily demand for each week group
 - d. Determine percent of time each weather condition occurs in each week group
 - e. Determine number of days represented (i.e., number of days in each week group multiplied by percent of time each weather condition occurs)
2. Calculate daily delay for each representative daily demand as follows:
 - a. Identify different runway uses which may be used
 - b. Determine percent of time each runway use occurs
 - c. Determine percent of daily demand occurring in each hour for each runway use
 - d. Calculate demand in each hour of the day
 - e. Calculate hourly capacity for each runway use

- f. Determine hourly delay for each hour for each runway use
 - g. Determine daily delay for each runway use
 - h. Estimate daily delay for each representative daily demand
3. Estimate annual delay from daily delays.

Inputs

The inputs for the annual delay aggregation model are stored in a file for processing by the model.

The five types of input data required to run the annual delay model are listed below.

1. Annual Demand: Number of annual operations.
2. Group Specification: Number of day groups (up to 7); week groups (up to 52); weather groups (up to 10); and runway uses (up to 10).
3. Weekly Traffic: Proportion of total annual traffic in one week of each week group.
4. Number of Weeks: In each group.
5. Daily Traffic: Proportion of weekly traffic in one day of each group.
6. Number of Days: In each day group.
7. Weather Group Demand Factors: Ratio of demand in each weather group to the demand in the first weather group. There are as many factors as weather categories.
8. Weather Occurrences: Proportion of occurrence of each weather group in any given week group (i.e., the sum of all weather group occurrences for any week group is 1.0).
9. Hourly Runway Capacity: Hourly runway capacities for each runway use and weather combination.

10. Runway Use Occurrences: Proportion of time each runway will be operated in the different weather conditions.
11. Hourly Traffic: Proportion of daily traffic to be distributed to each of the 24 hours.
12. Demand Profile Factor: (The proportion of peak-hour traffic in the peak 15 minutes.) This factor can take one of six values: 25, 30, 35, 40, 45, and 50.
13. Runway Use Demand Factor: Ratio of demand for each runway use to the demand for the first runway use. There are as many factors as runway uses.
14. Aircraft Mix: Mix for each runway use and weather combination. The mix should be that used to compute the hourly runway capacity.
15. User-Specified Title: Identifying alphanumeric name to be printed in the output.

Outputs

The outputs from the model are as follows:

- Average annual delay per aircraft
- Total annual delay to aircraft
- Distribution of average aircraft delays

The distribution of annual delay is computed and listed by time interval. Each time interval is printed only if the interval contains delayed aircraft.

III. OTHER ANCILLARY MODELS

A number of additional models can be used in the Task Force efforts to accomplish the analyses more efficiently, to permit greater depth of analysis, and to broaden the types of information that can be provided for evaluation of alternatives, including:

- A demand schedule preprocessor model that permits generation of aircraft movement schedules from Official Airline Guide (OAG) data and other data sources in a form that is compatible with the simulation model input requirements.
- A routing generator preprocessor model that simplifies the procedure of specifying aircraft routings on the airfield.
- Two postprocessor models that assist in interpreting the simulation model outputs. The postprocessors can generate statistics on mean values, standard deviations, and confidence limits, and can provide detailed distributions for user-specified parameters. Graphical plots of various kinds can also be developed.
- An Automated Radar Terminal System (ARTS) data model that analyzes data output from Federal Aviation Administration ARTS data extraction and reduction programs and processes the information into a format that is compatible with the simulation model input requirements.
- A weather model to analyze weather occurrence at an airport based on raw airport climatological data from the National Weather Records Center. This model permits development of wind, ceiling, and visibility data for input to airfield delay studies.
- A runway capacity model that computes hourly runway capacity based on user-provided inputs, including runway use, weather, percent arrivals, and aircraft mix.

Demand Schedule Preprocessor Model

The airfield simulation model requires input data covering aircraft demand on the airfield system. Data requirements are:

1. Aircraft identifier (e.g., flight number for air carrier aircraft)
2. Aircraft class
3. Arrival time
4. Departure time
5. Arrival fix and runway
6. Departure fix and runway
7. Preferred gate assignment (for air carrier aircraft) or basing area (for general aviation and military aircraft)

At air carrier airports, one available source of demand information is the Official Airline Guide (OAG), which is available in hard copy and in magnetic tape format. The OAG data contain data items 1, 2, 3, and 4 listed above.

The demand schedule preprocessor model extracts these items from the OAG data and combines them with other data to provide demand data for scheduled air carrier and air taxi operations. The output from the model can include a printed schedule and punched cards suitable for use with the PMM&Co. airfield simulation model.

Three sets of inputs are required:

- OAG arrival data
- OAG departure data
- User-specified data

Model output is the demand schedule, printed out or punched on cards as the user specifies.

Routing Generator Preprocessor Model

Routing data requirements for the airfield simulation model consist of defining the typical paths aircraft use between the runways and the apron areas. More specifically, routes have to be defined for each exit taxiway/gate (or basing area) combination and for each gate (or basing area)/departure-runway combination. In addition, if holding areas or penalty boxes are used, routes have to be defined to and from these locations. The routing generator preprocessor model minimizes the effort involved in identifying the many routes that are typically used at a large air carrier airport.

Input to the preprocessor model consists of defining typical routes in a fashion similar to that required for the airfield simulation model. However, the logic of the preprocessor model is such that once a particular sequence of links is defined on a route, it is possible to abbreviate subsequent routes that contain the sequence by specifying the first link, a minus sign ("-"), and the last link of the sequence.

When the routing preprocessor model encounters a minus sign, it assumes the link numbers adjacent to the minus sign are part of a previously defined route. The program then searches through previous routes until it finds one containing these two links. It assumes that the complete route includes all links in between these links.

The model then generates the proper route. This program considerably reduces the amount of work required to identify the routes and prepare the input data for the airfield simulation model. The output from the preprocessor model is formatted such that it is directly usable as input to the airfield simulation model.

Postprocessor Models

Varying levels of detail may be obtained from the PMM&Co. airfield simulation model. Even though these levels of detail are adequate for many applications, in some situations further levels of detail may be desirable. Examples include aircraft delays by airline and aircraft type. Two postprocessor models are available that use detailed information on individual aircraft movements generated by the airfield simulation model to provide additional analytic capabilities. One is a statistical postprocessor that generates frequency distributions, bar charts, and other data. The second is a graphical postprocessor.

The statistical postprocessor model utilizes the Statistical Package for the Social Sciences (SPSS) computer programs to derive user-specified statistical measures such as the mean, standard deviation, and confidence limits for a given parameter, and distributions of delay values, travel times, and queue lengths. SPSS is maintained as an application package by the Control Data Corporation at their Western Cybernet Center.

The statistical postprocessor program uses the FREQUENCIES subprogram contained in the SPSS package. The user manipulates various SPSS statements to control both the type of output, such as delays to arrival aircraft, and the form of the output, statistical measures, bar graphs, etc. The postprocessor is structured to use a specific output file from the PMM&Co. airfield simulation model as the input for statistical analysis.

The statistical postprocessor is currently structured to print three sets of outputs:

- Frequency tables
- Frequency bar graphs
- Statistical measures

These outputs can be obtained for any combination of delays and travel times for arrivals and departures. For the frequency tables and bar graphs the output data are rounded to the nearest integer. The frequency table output includes:

- Absolute frequencies
- Relative frequencies
- Adjusted frequencies
- Cumulative frequencies

The statistical measures include:

- Mean
- Mode
- Median
- Standard deviation
- Variance
- Kurtosis
- Skewness
- Range
- Minimum
- Maximum
- Sum
- Standard error of the mean
- Coefficient of variance
- 95% confidence interval for the mean

- Number of valid cases
- Number of missing cases

The graphic postprocessor model produces graphic plots of various data. Data may be delay values, travel times, or other data obtained from the PMM&Co. airfield simulation model. The postprocessor is structured to take an output file from a single run of the airfield simulation model and plot total arrival and departure delays by hour.

The graphic postprocessor model consists of two computer programs that utilize the DISSPLA plotting software developed by Control Data Corporation. The first program reads in the data and uses DISSPLA routines to build the plot file. The second program performs the plotting manipulations.

To build the plot file, the first program generates the proper inputs for the plotting routines. Maximum values and step sizes for both sets of data are determined, and arrays are established that contain the plotting points. Then, a series of plotting routines are called to develop axes, labels, titles, and the curves themselves. The output file is then cataloged for use as input for the second program.

The second program takes the output of the first program and creates a file that is graphically plotted by a CALCOMP plotter. The program also controls the disposition of the plots.

The output from the first plotting program lists the hours that will be plotted along the x-axis, the number of hours to be plotted, and the actual delay values to be plotted.

The output from the second program is a listing of the control cards for plotting and the actual plot.

ARTS Data Model

The ARTS data model analyzes output from Federal Aviation Administration ARTS III data extraction and reduction programs, and processes the information into a format that is compatible with inputs required by the airfield simulation model.

Capacities and delays at airports depend largely on aircraft separations which reflect operational procedures and air traffic control requirements. The Automated Radar Terminal System (ARTS) tracks individual aircraft. Data contained on Federal Aviation Administration ARTS III magnetic tapes

include aircraft location, identity, altitude, and time of observation. The PMM&Co. ARTS data model uses such data to determine relevant statistics on:

- Aircraft separation (both arrivals and departures)
- Approach and departure speeds
- Air traffic distribution over runways and coordinate fixes
- Utilization of each runway and coordinate fix

The ARTS data model requires three types of input from the user.

The first type of input is the output data from the Federal Aviation Administration ARTS III extraction and reduction programs. This tape records the movements of each aircraft studied, and is expected to be available from FAA. The information required by the PMM&Co. ARTS data model includes: aircraft identity; operation type (i.e., arrival or departure); the time that an aircraft passes through a coordinate fix, and the name of the coordinate fix; the time that an aircraft is at the runway threshold; and the runway used.

The second type of input is a correspondence table between aircraft identity and aircraft class. The model uses this information in compiling separation, velocity, and traffic distribution statistics by aircraft class. Such a correspondence table can usually be constructed using the Official Airline Guide. This table is read according to 8(1X,A6,1X,A1) format. Each card will contain eight pairs of aircraft identity (airline and flight identifiers) and the associated aircraft class.

The third type of input covers some airport-specific information. In all, 12 different items are required, including the number of runways and fixes.

The ARTS model produces information that can be used as inputs to the airfield simulation model. These include:

- Arrival-arrival separation distributions over runways and over fixes classified by aircraft class

- Departure-departure separation distributions over runways and over fixes classified by aircraft class
- Approach-speed distributions for arrivals and takeoff speeds for departures by aircraft class
- Utilization of each runway and fix
- Aircraft mix for each runway and fix

Weather Model

The weather model extracts and processes relevant information from airport climatological data compiled on magnetic tape by the National Weather Records Center in Asheville, North Carolina. The model analyzes weather data and presents pertinent information for airport planning purposes. The model first reads data on the weather center tape and then screens and transfers them to another magnetic tape in a form suitable for manipulation and analysis. Depending on the options the user chooses, the model can produce one or more sets of data on wind, ceiling, and visibility.

Analyzing aircraft operations at airports often requires detailed knowledge of how different weather conditions are distributed over a year. The National Weather Records Center keeps records of weather observations for most major U.S. airports. The PMM&Co. weather model manipulates data from such records to:

- Calculate and tabulate crosswind components on a runway or, in the case of a multiple-runway airport, on both primary and secondary runway orientations. The observations can be tabulated by hour of day and by month of year for specified crosswind velocity ranges.

The crosswind components are computed knowing information on wind direction and speed, and true runway orientation. This information is available by hour of the day and by month of the year and is cross-classified with information on ceiling and visibility.

- Tabulate the occurrence of various ceiling/visibility conditions by time of day and month of year.

- Estimate the number of aircraft that are delayed, diverted, or cancelled during wind conditions which close the airport. The frequency distribution of consecutive hours of specific weather conditions can also be tabulated to help the user in determining delays, diversions, and cancellations.

The number of arrival aircraft delayed, diverted, or cancelled is computed by comparing the weather records of individual days with a schedule of aircraft demand. The number of aircraft demanding service within specified excessive crosswind conditions is then computed and output.

The model logic allocates delays to aircraft which are subject to airport closures of one hour or less. For aircraft subject to airport closures of more than one hour, 20% are considered diverted and 80% cancelled, except for operations in the last hour which are all delayed.

This portion of the model was developed in response to a site-specific airport analysis requirement. In general, the handling of the impacts of airport closures is a complex problem which is best examined in a site-specific manner. Therefore, modifications to this portion of the model may be appropriate for analysis at other airports.

- Print out wind rose tables at a specific airport. This can be performed for any user-specified ceiling and visibility conditions and for any duration in a day (e.g., the 17-hour period between 0700 hours and 2400 hours, or the entire 24-hour day).

Wind rose tables can be developed for any specified sets of wind speed ranges and are presented for 16 points of the compass.

The occurrence of various ceiling and visibility conditions is given for up to seven different sets of conditions.

Three types of input are required to exercise the weather model.

All analyses performed by the weather model require the first type of input, which consists of three elements:

- The years for which weather data will be analyzed
- A header card containing the name of the airport and/or the run description
- Three groups of ceiling and visibility conditions for use in the analysis

The second type of input is a set of weather data for the airport being studied. The weather data are generally stored on magnetic tapes which can be obtained from the National Weather Records Center in Asheville, North Carolina.

The third type of input relates to the kind of analysis to be performed. A total of six options are available for analysis and different inputs are required in each case. The analysis options available are:

1. Data tape screening
2. Delay, diversion, and cancellation
3. Primary runway crosswind component
4. Primary and secondary runway crosswind component
5. Wind rose tables
6. Ceiling and visibility

The output from any individual computer run depends on the options selected for analysis. Output for each of the options is described in the following paragraphs.

Option 1--Data Tape Screening

The output of Option 1 is the screened and processed weather data for use with all other options.

Option 2--Delay, Diversion, and Cancellation

For the specified time period and crosswind speed ranges, the output of Option 2 gives the date, duration, and wind velocity for all occasions with excessive crosswind. In addition, for the specified demand schedule, the number of aircraft delayed, diverted, or cancelled is given for each occasion.

Option 3--Primary Runway Crosswind Components

For the specified runway azimuth and crosswind speed ranges, the output of Option 3 gives the number of weather observations in each crosswind speed range by hour of day and by month. This information is cross-classified with the number of weather observations in three specified ceiling and visibility conditions.

Option 4--Primary and Secondary Runway Crosswind Components

Output of Option 4 is identical to that of Option 3 except that the output is presented for both the primary and secondary runway azimuth, and that there is no classification according to ceiling and visibility conditions.

Option 5--Wind Rose Tables

For the specified wind-speed groups and time of day, the output for Option 5 gives the number of weather observations and percent occurrence of wind by 16 points of the compass. The data are also presented cross-classified by specified ceiling and visibility conditions.

Option 6--Ceiling and Visibility

For the specified ceiling and visibility conditions, the output for Option 6 gives the number of weather observations, by month and by year in each of the ceiling and visibility categories.

Runway Capacity Models

The runway capacity model calculates capacity as the inverse of a weighted average service time of all aircraft being served. The capacity model uses a set of input parameters to determine the minimum time separation (or interval) between operations. The time intervals are computed for different types of aircraft (e.g., Boeing 747 followed by Cessna 150) and for different types of operations (e.g., arrivals and departures), taking into account ATC rules, weather conditions, runway occupancy times, runway configuration, and aircraft operating characteristics. The time intervals are then averaged and inverted to produce the capacity estimates.

Inputs

The inputs required for the runway capacity models include:

1. Ceiling and Visibility. For capacity computation purposes, ceiling and visibility can generally be divided into four sets:
 - VFR1--VFR conditions that allow simultaneous operations on close parallel runways.
 - VFR2--VFR conditions that do not allow simultaneous operations on close parallel runways.
 - IFR1--IFR conditions that allow relief from the two-mile departure-arrival separation rule.
 - IFR2--IFR conditions just above operating minima.

Depending on the extent of information required to meet study objectives, analysis of weather conditions and ATC operating procedures may be required.

2. Runway Use. Runway use is defined in terms of the number, location, and orientation of active runways and involves the directions and kinds of operations using each runway. Analysis of wind conditions and runway constraints (e.g., noise, airspace, obstructions) may be required to select appropriate runway uses.

3. Aircraft Mix. Aircraft mix is defined in terms of four aircraft classes: A, B, C, and D, as shown in the following tabulation:

Aircraft Classi- fication	Types of Aircraft ^a
Class A	Small single-engine aircraft weighing 12,500 lb ^b or less (e.g., PA18, PA23, C180, C207)
Class B	Small twin-engine aircraft weighing 12,500 lb ^b or less and Lear jets (e.g., PA31, BE55, BE80, BE99, C310, C402, LR25)
Class C	Large aircraft weighing more than 12,500 lb ^b and up to 300,000 lb ^b (e.g., CV34; CV58; CV88; CV99; DC4; DC6; DC7; L188; L49; DC8-10, 20 series; DC9; B737; B727; B720; B707-120; BA11; S210)
Class D	Heavy aircraft ^c weighing more than 300,000 lb (e.g., L1011; DC8-30, 40, 50, 60 series; DC10; B707-300 series; B737; VC10; A300; Concorde; IL62)

-
- a. For aircraft type designators, see FAA Handbook No. 7340.1E with changes.
- b. Weights refer to maximum certificated takeoff weight.
- c. Heavy aircraft are capable of takeoff weights of 300,000 lb or more whether or not they are operating at this weight during a particular phase of flight. (Reference FAA Handbook 7110.65 with changes.)

The proportion of aircraft in each class during the hour for which capacity is to be calculated should be obtained by examination of tower counts, field surveys, etc. If the mix differs between runways because of runway restrictions etc., the mix on each runway should be given.

4. Percent Arrivals. The percent of all aircraft operations that are arrivals. Information can be obtained by examination of tower counts, field surveys, etc.
5. Percent Touch-and-Go. The percent of all aircraft operations that are touch-and-go (training) operations. A touch-and-go operation is counted as two aircraft operations (an arrival and a departure). Information can be obtained by examination of tower counts, field surveys, etc.
6. Exit Configuration. The location and type of each exit taxiway on runways used for arrival aircraft operations. The Airfield Layout Plan or similar sources can be used to obtain the information.
7. Runway Occupancy Times. Arrival, departure, and touch-and-go occupancy times in seconds by aircraft class. Arrival runway occupancy times are required for each exit, together with the percent utilization of each exit by each aircraft class.
8. Aircraft Separations. Consistently achievable minimum separations between aircraft. Separation values are needed by each pair of aircraft classes (e.g., Class A followed by Class B).
9. Common Approach Path Length. The length of the straight-in approach along the extended runway centerline (for which the controller cannot exert speed control) in nautical miles for each aircraft class.
10. Approach Speed. The mean approach speed in knots of each aircraft class over the length of the common approach path.
11. Clearance Time. For airports with intersecting runways, mean arrival and departure intersecting runway clearance times in seconds by aircraft class.

Output

The output from the model is the hourly runway capacity of the runway use under consideration. The capacity computed represents the maximum number of aircraft operations that can take place on the runway(s) under the specific conditions studied.

Appendix B

IMPROVEMENT ITEMS

Source: Los Angeles International Airport Improvement
Program Interim Report.

LOS ANGELES AIRPORT IMPROVEMENT STUDY
ITEMIZED LISTING OF NEAR TERM IMPROVEMENTS.

1. Upgrade to Category II or better the runway environment and electronic installations for all runways - LAX and FAA §2
2. Provide high speed taxiway off of Runway 25L to the south - FAA and LAX §2
3. Strengthen the Sepulveda tunnel - FAA and LAX §2
4. Simplify Standard Instrument Departure Procedures (SIDs) - FAA §2
5. High speed taxi exit off Runway 7 - LAX and FAA §2
6. Fog dispersal system for Runway 24R - LAX *Deferred*
7. High speed taxi exit to Taxiway 47 from Runway 6R - LAX and FAA §7
8. Bypass area on the north side of Runway 7L - FAA and LAX §7
9. Extend Runway 24R to 10,285 feet - FAA and LAX §7
10. Improvement of Taxiways - FAA and LAX
 - a. Relocate Taxiway 47 to the west §2
 - b. Extend Taxiways 47 and 49 to the south to connect with Taxiways J and K §2
 - c. Extend Taxiways J and K to the west to connect with Taxiways 47 and 49 §2
 - d. Build Two Taxiways to connect Taxiway 45 with Taxiway 49 west of Satellites 3 and 4 §2
 - e. Reconstruction of Taxiway F *new*
11. Build temporary holding areas on present Taxiway 47 west of Satellites 3 and 4 - LAX and FAA *not at all if Int. Building, land*

Discussion

The following paragraphs outline the justification and probable funding of each prioritized improvement. The improvements are grouped according to the responsible initiating organization. Priorities have been indicated for the two most critical items.

Initially the desire was to present approximate costs and benefits for each recommended improvement so as to provide a measure of the economic gain anticipated from the project. The request was then made to the

Airports and Airway Facilities Division of the FAA to provide "ball park" estimates of the costs involved in the construction, operation and maintenance of the various capital improvements recommended. At the same time the Air Transport Association agreed to attempt an estimate of the benefits, in terms of delay cost savings, expected to be derived from the improvements.

As a result of the above request, "ball park" figures were provided as estimated costs for each prioritized improvement. These "ball park" costs are included in this report, but it must be kept in mind that they could change significantly depending upon the final operational requirements. Also, approximate dates when funds are expected to be available have been included.

As the benefits were being estimated it was found that even "ball park" figures were difficult to determine due to the number of variables which have not been quantified. It was, therefore, decided not to include benefit estimates in this report, but to wait for the completion of the delay model computations.

Priority Items

Priority 1 — Strengthen the Sepulveda tunnel and remove the widebody restrictions now in effect.

Initiating Responsibility — FAA and LAX

The major cause of departure delays at LAX is the inability to distribute the traffic efficiently on the two runway complexes. The removal of these restrictions would enable the tower to direct departing aircraft to the runway most compatible with their route of flight or originating terminal location. LAX departure delays are compounded by southbound aircraft departing the north complex and then crossing the path of those waiting to depart off Runway 25L/R.

In addition, remove the restrictions on all runway use and allow an uninhibited flow to occur, both for arrivals and departures.

When visual approaches are in progress, the approach controller normally sequences all inbound aircraft to the south complex unless they are widebodies and weigh more than 325,000 pounds. This effectively causes 83% of the traffic to land on the south complex. The resultant buildup on this side of the airport has obvious disadvantages. The local controller is extremely busy, normally with backed up departures and the ground controller has the great majority of his traffic concentrated between the four high speed turn-offs and adjacent terminals. Since there are twice as many unit terminals on the south side, congestion is inevitable. If inbound traffic was sequenced to the runway most compatible with the aircraft route and/or to the runway nearest the destination terminal, most of this difficulty could be avoided.

Additionally, Runway 24R is inhibited for departures due to noise abatement. This restriction is lifted when a closure of some other runway affects the traffic flow. This means that all departures off this complex must depart 24L, reducing the local controller's flexibility and causing significant delay. (Aircraft weighing less than 12,500 pounds may depart 24R.) During periods of serious delay, it is the supervisor's option to authorize departures off 24R.

Although LAX has four full service runways and adequate airspace, the same congestion occurs daily at certain portions of the airport. If we used our facilities according to the requirements of the traffic, the delays would be drastically minimized. A system that very often requires 83% of its traffic to use 50% of the runways and taxiways creates delays.

New procedures would naturally be written to take full advantage of the removal of all restrictions on the runways.

The Los Angeles Department of Airports already includes the tunnel reconstruction and closely related work in their planning for 1978-1980.

The estimated cost of the Sepulveda upgrading project is \$16,075,000. Removal of other current restrictions to full use of the LAX runways requires a change of policy.

Alternative to Priority #1 - Extend Runway 24R to 10,285 feet

Initiating Responsibility - FAA and LAX

Since widebody aircraft weighing more than 325,000 pounds may only use the north complex, any time that Runway 24L is closed, Runway 24R is their only remaining departure runway. This causes serious problems for those aircraft too heavy for the shorter runway, although this is normally confined to long haul westbound operations (Honolulu, Tokyo) or transcontinental flights. These aircraft have no alternative but to reduce takeoff weight through payload and/or fuel restrictions. If the Sepulveda tunnel is strengthened and the widebody restrictions are removed there would be three runways of adequate length for the long haul flights.

The Department of Airports presently includes this improvement in their planning for 1980-1982, however, extension of Runway 24R is not presently listed in the ATA Survey of Airports.

The estimated cost of the project is \$2,068,000.

Additional Recommended Improvements

High Speed Taxiway Off of Runway 25L to the South

At present, there is no exit of this type. This would be a prerequisite for any expansion of facilities on the south ramp area. Presently, if

traffic is a factor, any aircraft that does not make the Sepulveda turn-off is given a right turn off the runways and recrossed by the ground controller. Obviously, any increase in traffic would make this procedure impractical. This also is included in the Department of Airports' planning for 1978-1980 and the project is included in the strengthening of the Sepulveda tunnel.

Simplify Standard Instrument Departures (SIDs) Procedures

This adoption would significantly reduce the number of pages in the pilot's instrument approach book as well as result in a considerable monetary saving to the carriers by reducing the number of SID revisions they must pay for.

In view of the fact that for many years the departure environment at Los Angeles has been the "radar drive" concept, with the SIDs for all practical value being only a lost communications back-up, we feel the common SID should be adopted. Two major airports already have a common SID (DEN/ORD). SID/STAR procedures are currently undergoing review at the Washington level.

High Speed Exit Off Runway 7

With the advent of the over-ocean approach for sound abatement, plus the normal requirements of east traffic, this exit is necessary. Without adequate high speed turnoffs, the approach interval must necessarily be increased. This improvement is also included in the Department of Airports' plans.

High Speed Taxi Exit to Taxiway 47 from Runway 6R

At present, the turnoff is a 90° turn. Installation of a high speed exit will permit a quicker clearing of the runway by aircraft required to land on Runway 6R during an east traffic configuration. An improved smoother uninterrupted flow of aircraft off of the runway will increase capacity.

Improvement of Taxiways

This is necessary to permit simultaneous two-way taxi operations for north and southbound aircraft. This will also permit two-way taxiing for east/westbound aircraft.

Temporary Holding Areas

Temporary holding areas are needed for aircraft that do not have a gate assignment.

Current and Approved Projects

Electronic and Runway Environment Improvements

The following is a list of the F&E programs for Los Angeles International Airport that are current projects either in progress or approved for start at some future date:

A. Runway 24R

1. ALSF - Convert from ALSF-1 to ALSF-2 (to be compatible with CAT IIIA ILS)
2. ILS - Convert CAT II to CAT IIIA

B. Runway 24L

1. SSALR - Modify SALS - add RAIL lights
2. Modify localizer antenna

C. Runway 25L

1. ALS - Convert to CAT II
2. ILS - Convert to CAT II (complete). IM is complete but awaiting CAT II operational capability.
3. RVR - Add midfield.

D. Runway 25R

1. Replace obsolete glide slope

E. Runway 06L

1. ILS CAT I establish
2. MALSR establish

F. Runway 06R

1. MALSR - Provide frangible towers
2. Modify localizer antenna

G. Runway 07L

1. MALSR - Provide frangible towers

H. Runway 07R

1. ILS CAT I establish
2. MALSR establish

I. ASR

1. Various technical modifications to improve performance

J. ASDE

1. Add BRTE 4
2. Add improvement modifications

K. ARTS

1. Provide additional memory
2. Various other technical improvements

L. SECRA

1. Modify or replace antenna

Appendix C
INPUT DATA FORMS

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[illegible]

LINK DATA FORM

Los Angeles International Airport
Delay Improvement Study
PMM&Co. September 1978

GATE DATA

[illegible]

Figure C-2

C-2 GATE DATA
Los Angeles International Airport
Delay Improvement Study
PMM&Co. September 1978

[illegible]

SEPARATION DATA FORM
Los Angeles International Airport
Delay Improvement Study
PMN&Co. September 1978

ROUTE DATA

[illegible]

ROUTE DATA FORM
Los Angeles International Airport
Delay Improvement Study
PMM&Co. September 1978

AD-A099 854

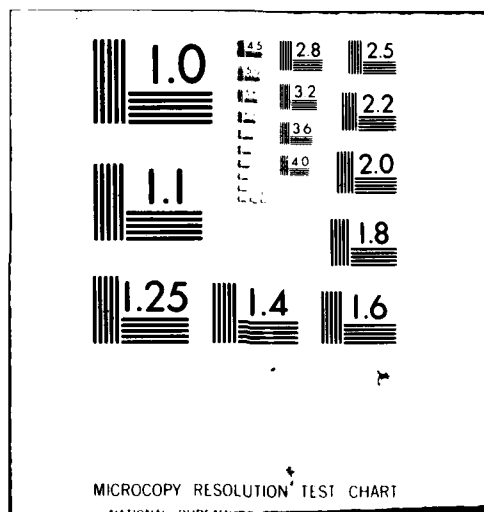
PEAT MARWICK MITCHELL AND CO SAN FRANCISCO CALIF F/G 1/5
LOS ANGELES INTERNATIONAL AIRPORT TECHNICAL PLAN. AIRPORT IMPRO-ETC(U)
SEP 78 DOT-FA77WA-3961
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2 of 2
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Airline _____

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- Figure C-5**

AIRCRAFT GATE SERVICE TIMES
Los Angeles International Airport
C-5 Delay Improvement Study
PMM&Co. September 1978

AIRFIELD SIMULATION MODEL

RUNWAY/FIX TRAVEL DATA

[illegible]

Figure C-6

C-6

AIRSPACE TRAVEL TIME DATA FORM
Los Angeles International Airport
Delay Improvement Study
PMM&Co. September 1978

ARRIVAL AIRCRAFT LATENESS DISTRIBUTION
(Average deviation from schedule, excluding delays
due to destination airport)

Airline _____

Percent of flights late or early (%)	Amount of time Late or early
	More than 30 minutes early
	15 to 30 minutes early
	Less than 15 minutes early
	On time
	Less than 5 minutes late
	5 to 10 minutes late
	10 to 15 minutes late
	15 to 30 minutes late
	30 to 45 minutes late
	45 to 60 minutes late
	More than 60 minutes late

Total 100%

Figure C-7

ARRIVAL AIRCRAFT LATENESS DISTRIBUTION
Los Angeles International Airport
Delay Improvement Study
PMM&Co. September 1978

DEMAND DATA

[illegible]**DEMAND DATA FORM**

**Los Angeles International Airport
Delay Improvement Study
PMM&Co. September 1978**

September 1978